RESPONSE OF HYBRID RICE AND WHEAT TO DIFFERENT SOURCE OF NITROGENOUS AND PHOSPHATIC FERTILIZERS

THESIS

Submitted in partial fulfillment
Of the requirement for the award
of
the degree of

DOCTOR OF PHILOSOPHY

To

ALLAHABAD UNIVERSITY

By
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DEDICATED

TO

MY BELOVED PARENTS

Shri. Dharmendra Singh

&

Smt. Tara Devi

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CERTIFICATE OF ORIGINAL WORK

This is to certify that study conducted by **Mr. VIKRAM SINGH** during 1998-2000 as reported in the present thesis work was under my guidance and supervision. The results reported by him are genuine and the script of this thesis has been written by candidate himself.

The thesis entitled **"RESPONSE OF HYBRID RICE AND WHEAT TO DIFFERENCE SOURCES OF NITROGENOUS AND PHOSPHATIC FERTILIZERS"** is therefore, being forwarded for the acceptance in partial fulfillment of the requirements for the degree of **DOCTOR OF PHILOSOPHY IN AGRONOMY** of Allahabad University.

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ACKNOWLEDGMENT

I take this opportunity to express my profound and heartful thanks to my guide Dr. S.S. Singh, Professor and Head, Department of Agronomy, Allahabad Agricultural Institute-Deemed University, Allahabad, for his invaluable and painstaking guidance, constructive and creative criticism and prolific encouragement at every stage of this study. His fitial love, enduring patience coupled with amicable amiable and facetious nature was the things that gave me access to discuss the related matters at any odd hours of the day. There is no denying the fact, that his able guidance has gone a long way making this into a congent and consistent thesis.

I owe a debt of gratitude to Dr. Mohd. Kalim, Dr. Gautam Ghosh, and Dr. Joy Dosan and Dr. P.C. Jaiswal Ex-Professor, Department of Agronomy, for their keen and kind suggestions, co-operations and encouragement for the successful completion of this investigation.

I am grateful to Mr. S.B. Lal Dean and Head College of Agroforesty, Dr. Thomas Abraham Assoc. Professor. It is a great pleasure to acknowledge the unstinted support rendered by Dr. D.B. Singh Head, Department of Horticulture, Dr. Gauri Shanker, Emeritus Scientist of Horticulture Department and Mr. Ram Lal, Department of Mathematics and Statistics for their timely help and technical guidance in the analysis of data.

Words fail to express my deep gratitude to my Mummi (Smt Tara Devi), Papa (Shri Dharmendra Singh), elder Sister (Vinita Singh), loving brother (Praveen Singh) for their sacrifices encouragement and inspiration during my study period.

Last but not least I am also greatful to Kulbir Singh and Syed Fiyaz Andrabi for typing this manuscript.

Date :

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CHAPTER- I

INTRODUCTION

INTRODUCTION

Great strides have been made in agricultural production since sixties following massive application of a science and technology, which helped in transforming Indian agriculture from the subsistence type to a commercial farming system. The impact of research and development efforts is reflected in the achievement of self sufficiency in food grain production from 51.00 million tonnes in 1950-51 to a record production of about 208.80 million tonnes in 1999-2000 of which rice accounts for 89.40 million tonnes and wheat accounts for 75.50 million tonnes. (The Hindu Survey of Indian Agriculture 2002). Despite these achievements, the Indian agriculture continues to face serious challenges due to increasing population, depleting land fertility and shrinking non-renewable energy resources. As a matter of fact the future of Indian food security and economy depend largely on desired rice and wheat production.

Rice is a crop of paramount importance in India, as it is the staple food of all the sections of the society. It provides more calories/ha than any other cereal crops. It is estimated that one hectare of rice can sustain 5.70 persons for a year compared to 5.30 for maize and 4.10 for wheat based on average world yield levels. (F .A.O. Production Year Book 1998). It contributes to 45% of the total food need. India stands first in area having about 47.00 million hectare and second in production giving about 84.74 million tonnes, sharing almost 72% in total world rice production. About wheat India is second largest wheat growing country in the world wheat occupies commanding position in Indian agriculture and is grown over an area of 24.60 million hectares with a total production of 75.5 million tonnes in 1999-2000 (The Hindu Survey of Indian Agriculture 2002) India

occupies about 4 % of the world cropped area and feeds 15 % of world's population. Wheat is an important winter season cereal occupying 52.80 percent of total *rabi* food grains. It is cultivated throughout the world on an area of about 132.00 million hectares with 595.00 million tonnes total production (Fertilizer Statistics 1996). The area covered under the wheat crop has increased from 9.25 m ha in 1950-51 to 24.60 million ha, similarly the productivity during the period has enhanced round about four fold from 6.63 q/ha in 1950-51 to 26.92 q/ha in 1995-96 (fertilizer statistics 1996). Of the total area under wheat it is found to be 36 % in Uttar Pradesh and 13 % in Punjab. It is interesting to note that wheat area in Punjab is 3.50 m ha but the productivity is 3.58 t ha^{-1}. The increase in production and productivity has been the result of the development and cultivation of semi dwarf, fertilizers and water responsive varieties which have better potentials than taller varieties (Gill 1994). This is mainly because of the higher rate of consumption of nutrients (N.P. & K.) being 171.12 $kgha^{-1}$ in Punjab & Haryana as against 90 kg ha^{-1} in U.P. during 1994-95 (Fertilizer Statstics 1995).

At the present level of production, India would have to add 2.50 million tonnes of rice annually to sustain the present level of self sufficiency. Considering the present production scenario of 81.00 million tonnes, it does not appear to be an easy task to achieve the target production of 95 -100 million tonnses in the next 5 years. Moreover, the total rice production has remained static for the last 10 years with an average productivity of 3.10 tonnes/ha, which is far below the world average. This situation calls for more attention and effective management. Since there is hardly any scope for bringing more area under rice cultivation the only option left is to improve the yield per unit area at not less than 3.0-3.5% annual growth.

Fertilizer is the most important and indispensable input in crop production. But the high cost of fertilizer warrants its efficient usage, to optimize its return. This is much more important when its cost benefit ratio is under pressure, from the high cost of fertilizer and comparatively static cost of agricultural produce. Crop responds to chemical fertilizer is related to certain properties of individual nutrient sources, soil and crop characteristics and this is very true in the case of nitrogen and phosphorus which plays a key role among the nutrients essential for plant growth.

Nitrogenous fertilizers such as Urea, Ammonium sulphate, Calcium ammonium nitrate and Ammonium chloride, and Phosphatic fertilizers such as Diammonium phosphate, Single super phosphate and Nitrophos are the commonly available and used ones. The consumption of these fertilizers in the country has increased many fold during the past few years, from negligible quantity in 1950 to over 13.00 million tonnes of nutrients or over 28.00 million tonnes of fertilizer materials in 1992-93, with the introduction of high yielding varieties, tendency towards intensive farming and use of modern agricultural technology. Thus rice growing has assumed a new and important dimension. Though there has been many fold increase in the use of fertilizer added to soil per hectare still it is very low in comparison to agriculturally advanced countries and the recovery of applied fertilizer in India is very poor ranging between 23.00 to 30.00 percent. Consequently the fertilizer use efficiency is also very poor. The reason being that the fertilizer consumers are mostly illiterate and unaware of proper handling and application method of the materials which need to bring about revolutionary changes in the concept, belief and practices of our farmers.

The existing experimental evidence shows that it is not adequate to find the relative efficiency of different nitrogenous and phosphatic fertilizers

on paddy and wheat under the Allahabad conditions. Therefore, an experiment was carried out during *Kharif* and *Rabi* season of 1998-99 and 1999-2000 aimed at selection of best source of nitrogenous and phosphatic fertilizers amongst locally available materials in the market at Crop Research Farm, Agronomy Department, Allahabad Agricultural Institute- Deemed University, Allahabad with the following objectives:-

1. To evaluate the suitable nitrogenous fertilizer to maximize the productivity of rice and Wheat.
2. To evaluate the suitable phosphatic fertilizer to maximize the productivity of rice and Wheat.
3. Interaction effects, if any.
4. To study the relative economics of different combinations.
5. To study the qualitative aspects as influenced by various Nitrogenous and Phosphatic fertilizers.

CHAPTER- II

REVIEW OF LITERATURE

REVIEW AND LITERATURE

A review of the available literature on the impact of Nitrogen and Phosphorus sources on growth and yield of Rice and wheat is presented in this chapter.

There are different opinions among the scientists who have done work on the relative efficiency of different nitrogenous and phosphatic sources of fertilizers on the growth and yield of rice and wheat. Many findings of the research works are cited below.

According to an annual report of International Rice Research Institute, Philippines (1974) for low land rice, both urea and ammonium sulphate fertilizers have been found to be satisfactory sources of nitrogen in most flooded tropical rice.

Raghavatu *et al.* (1975) of the All India Coordinated Agronomy Experiment Scheme, Hyderabad reported in their trials on alkali Soil (pH-8.5) with low land rice given 60 kg P_2O_5 + 60 kg K_2O/hectare, application of 120 kg N/ha in 3-4 equal split dressings at transplanting and at the panicle initiation stage gave higher paddy yields (4.79-4.9 t/ha) than when applied in two split dressings at transplanting and at the panicle initiation stage. Rice yields (5.16 t/ha) were obtained highest with N supplied as ammonium sulphate (AS) than as urea, Calcium ammonium nitrate (CAN) or ammonium Sulphate nitrate (4.3-4.64 t/ha).

Raghavatu *et al.* (1975) conducted research at Central Rice Research Institute, Cuttack and stated that Ammonium Sulphate and Urea are equally efficient in increasing rice yield.

Donabue (1965) stated that ammonium sulphate and urea are equally effective for paddy.

Thakur and Saxena (1970) also found that ammonium sulphate and urea are equally efficient.

In 1968 (Jayaraman, Swaminathan and Mariakutudae) found that on equal Nitrogen doses there is not much difference between ammonium sulphate and urea performance.

Daji (1965) reported that ammonium sulphate is most suitable for paddy than urea.

Thakur (1967) while comparing the relative performance of different nitrogenous fertilizers found ammonium sulphate as a better fertilizer than urea.

Kulkarni *et al.* (1975) reported that ammonium sulphate gave the best performance than urea in low land paddy.

In 1975 Raghavalum and Sreramamurthy reported that higher yields of rice were obtained with ammonium sulphate than urea.

Tiwari (1965) reported that urea is a good source of nitrogen for paddy and it can easily replace Ammonium Sulphate.

Malik and Das (1965) reported that Ammonium Sulphate was better source of Nitrogen for paddy.

Mishra and Singh (1968) concluded that, in black soil Ammonium Sulphate is superior to urea while in saline soil urea is superior to Ammonium Sulphate as source of nitrogen for paddy.

Sreedharan and George (1968) reported that CAN was superior to AS in increasing the yield of paddy.

Subrahmanyan (1965) reported that as a source of Nitrogen for paddy under coimbatore condition AS was superior to CAN.

Krishnan (1968) stated that AS is slightly superior to CAN in all growing seasons.

Patil and Despande, (1973) reported that Nitrogen applied in ammoniacal form (as AS) increased the yield of both grain and straw over nitrate form (as CAN).

Amongst the AS & CAN as a source of N, AS has given the best performance in increasing the yield of paddy (Kulkarni, Ragumwithy, Sadasivah 1975).

Donahue (1965) stated that for top dressing on paddy calcium ammonium nitrate is almost as effective as Ammonium Sulphate.

Kalyankutty (1967) on the contrary found that there was no significant difference in yield among the different source of N such as AS and CAN.

Das and Chatterjee (1980) of Bidhan Chand Krishi Viswa Vidyalaya Kalyani, conducted field experiments in both wet and dry seasons with N-serve treated and un treated with Urea and calcium ammonium nitrate. The result showed that N–serve treated fertilizer supplements with split application of N increased paddy yield by 12-17% in wet and 14-21% in dry seasons over the conventional method of N- application in split doses. The maximum responses to N utilization of applied N, LAI at flowering and from flowering to maturity were observed in N-serve treated urea followed by N-serve treated with CAN. The ammonical nitrogen content in soil at panicle initiation, flowering and harvest of rice was also high whereas N-serve produced higher 1000 grain weight. Grain yield increased by 28, 46 and 57% over untreated control with application of 60, 120 or 180- kg N/ha and yield response/kg applied nitrogen was 22, 16 and 14 kg grain respectively. Nitrogen application also increased protein yield and decreased number of days to flowering and protein yield/kg applied nitrogen. There was no significant difference on these parameters between the form of applied N, although grain yield tended to be higher with application of Urea, the flag leaf area was significantly and positively correlated with grain yield.

Mahalingam *et al.* (1975) of Agriculture College and Research Institute Coimbatore in a pot experiment in rice with application of 60 kg N/ha as green manures (GM), Calcium ammonium nitrate (CAN), Ammonium Sulphate (AS), GM + AS and GM + CAN increased paddy yields from 4.4g/Pot to 7, 7.30, 5.60, 8.60 and 7.40 g/pot respectively.

We Jingai (1995) of the soil and fertilizer, Jiagsa Academy of Agricultural Sciences China in a long term experiment, application of

ammonium chloride increased nitrogen utilization, crude porction and amino acid contents of rice, wheat and rape.

The data obtained from the All India Coordinator Agronomic Experiments Scheme during 1960-63 have been summarized by Gautam *et al.* (1967) and Bains *et al.* (1970) who reported that the response was highest with super phosphate followed by nitrophos (containing 50% water soluble phosphate). The least response were obtained by palassut engrain chemical nitrophos (no water soluble phosphate). In a subsequent analysis of these data Prasad *et al.* (1971) observed that nitrophos gave lower responses on neutral to alkaline soils but was as effective as or even more effective than superphosphate on acid lateritic and submountane soils.

Sahu *et al.* (1970) working with rice on red soils of Orissa and Mehrotra (1970) working on alluvial soil of U.P. reported that super phosphate is superior to nitrophos in case of rice crop.

Experiments conducted at the Central Rice Research Institute, Cuttack, Rao *et al* (1970) with ammonium phosphate and complex fertilizers including nitrophos on low land clay loam soil of Mahandi (pH-5.8) showed higher response with ammonium phosphate than with nitrophos.

In pot experiment with red and black soils of Andhra Pradesh, Venkateswarly *et al.* (1970) also found that the yield of grain and straw of rice HR-19 was not significantly different when Super Phosphate and nitrophos were applied with or without green manure.

Gumaste and Patil (1970) conducted incubation studies with surface soil samples of red (pH-6.4) and black (pH 7.4) soils of Dharviar with three levels of phosphorus supplied as superphosphate, nitrophos and fused magnesium phosphate and eliminated the available phosphorus 15 and 60 days after incubation. The available phosphorus was higher with super phosphate than with nitrophos.

Sahu *et al.* (1970) studied the residual effect of phosphate applied to rice on the succeeding crop of rice and observed higher residual effect with nitrophos than with superphosphate, though the difference was small.

Maxton (1927) reported that fertilizers cause greater reduction in germination than any other factor by destroying the seedling before it emerges through surface of the soil. The injurious effect is generally higher when the fertilizers are applied in contact with the seed, than when it is applied separately. Fertilizers arranged in the decreasing order of reducing the germination of clover and grases were ammonium sulphate, Urea and ammonium nitrate.

Court *et al.* (1962) and Boghuszewski *et al.* (1964) reported that at high doses of urea had bad effect on maize and rape in early stages of their growth.

Saxena (1966) conducted an experiment to study the response of wheat Cv P.B.–591 to source of nitrogen at the Regional Research Station, Nawalgony (Bareily) U.P. during the years 1959-60 and 1960-61 the results are summarised as the application of ammonium sulphate significantly increased the height of the plants, number of tillers and number of grains per

ear and grain yield. Blood meal has the next best treatment. The relative response to these sources of nitrogen was higher tham FYM or control treatmentss.

Gasser and Iordan (1967) found that application of fertilizers containing nitrate nitrogen produced more dry matter than ammoniacal nitrogen in wheat and oats, when the fertilizers were applied in the later stages of their growth.

Gilbert and Pucker (1967) noticed an inhibiting effect of urea on the early seedling development stage in safflower. However, the yields of the same were not affected by urea application amongst four nitrogenous fertilizers (*viz.* CAN, AS, ACl, and Urea) performance of urea was best.

Misra and Singh (1968) found that calcium ammonium nitrate gave significantly higher yield of total dry matter in rice than others. It also increased the height of the plants.

Lehr (1950) noticed from plant analysis data that crops recovered much less nitrogen from ammonical source than from nitrate form.

Ray chaudhari *et al.* (1965) reported better performance of nitrate fertilizers than the ammonical and amide forms of fertilizers on wheat.

Borkowski and Kozera (1956) reported that calcium nitrate gave higher yield of grain and straw as well as protein content of the oats. Later application of the fertilizer decreased the grain yield however, the protein in the grain increased.

Volk and Tidmore (1954) tried ammonium nitrate, urea and certain natural organics on oat and millet and found that overall recovery of nitrogen was 53.90 percent from urea and 72.80 percent from ammonium nitrate.

Sengupta and Das (1962) reported that due to application of 20 lb, 40 lb and 60 lb nitrogen as urea increased by 4.00 mt and 9 mt per acre respectively over control and the increase in response over ammonium sulphate at the three levels were 0.20 mt 1.00 mt and 2.0 mt respectively.

Ramasubramomi *et al.* (1962) reported that there is not much harm in using calcium ammonium nitrate in fertilizer mixtures. They found that calcium ammonium nitrate is mixed with super phosphate will lose its value due to conversion and it will become unavailable to plants. But the result of this study showed that the fixation itself is not so complete as to cause complete disappearance of all water-soluble P_2O_5.

Venkatarao (1964) reviewing the ten years data of fertilizer experiments on ragi has pointed out that the nitrogen in the form of chilean-nitrate was found to be better than ammonium sulphate.

Iruthayaraj and Rajarathnam (1965) found that calcium ammonium nitrate was as efficient as ammonium sulphate and urea in increasing grain yield of Cv CO-7 of ragi.

Roy chaudhari (1965) concluded that ammonium sulphate is better so far as its keeping quality and response to crops are concerned. In neutral and

alkaline soils citrate soluble phosphate may be as effective as water soluble phosphate if applied along with organic matter.

Indian Agricultural Research Institute (1959) evaluated relative efficiency of phosphatic fertilizers in principal Indian soils using the tagged atom technique have shown that for wheat on black soil mono and diammonium phosphate, monocalcium phosphate and super phsophate were made effectively utilised than dicalcium phosphate and ammoniated superphosphate.

Chaudhari and Balra (1992) conducted research at Central Rice Research Institute, Cuttack and stated that ammonium sulphate is efficient in increasing rice yield while calcium ammonium nitrate is slightly inferior.

Rangiah (1967) suggested that there was no significant difference between the yields obtained due to calcium ammonium nitrate, ammonium sulphate and urea as the different sources of nitrogen to supply the nitrogen content of fertilizer mixture. However, he concluded that application of calcium ammonium nitrate gave slightly higher economic returns than others.

Chinnaswami *et al.* (1967) found that calcium ammonium nitrate was found to be better in acid soil than in calcareous soil.

Gumoste and Patil (1970) conducted incubation studies with soil samples of red soil (pH 6.40) and black (pH 7.40) soils of Dharwar with three levels of phosphorus supplied through super phosphate, nitrophos and

fused magnesium phosphate and eliminated that the available phosphorus was higher with super phosphate than with nitrophosphose.

Sreedharan and George (1968) reported that calcium ammonium nitrate was superior to other nitrogenous fertilizers such as urea and Ammonium sulphate.

Rao (1970) conducted experiments at the Central Rice Research Institute, Cuttack with ammonium phosphate and complex fertilizers including nitrophos on low land clay loam soils of Mahendi alluvial (pH 5.80) showed higher response with ammonium phosphate than nitrophos.

Kumar Sastri (1970) reported that there was not much difference between super phosphate and nitrophos.

Zhang (1993) studded the effect of phosphate on winter wheat and application technique were conducted in 123 experimental sites in 15 countries and cities in 1986-89 with on experimental area of 1.70 million ha. The fertilizers used were home produced nitrophos, diammonium phosphate, ammonium nitrate and super phosphate application of 37.50 kg/mu nitrophos increased yield by 101.80 kg/mu an increase of 57.43% compared to control.

CHAPTER- III

MATERIALS AND METHODS

MATERIALS AND METHODS

A Field experiment was carried out under present investigation which needed different materials and methodologies for various studies made in field and laboratory. The methodologies followed and materials utilized during the course of investigation are concisely described in this chapter.

EXPERIMENTAL SITE:

The site of experimental field was at Agronomy Crop Research Farm, College of Agriculture, Allahabad Agricultural Institute- Deemed University Allahabad. This comes under subtropical zone of Indo Gangetic plains having alluvial soil and lies at 81.50^0 East longitude and 25.57^0 North latitude with an elevation of about 98.00 meters from sea level. The experimental field has good tube well irrigation and good drainage facilities.

CLIMATE:

This region has a sub tropical climate prevailing in the south-east part of Uttar Pradesh with both the extreme of temperature, in winter temperature some times fall very low up to 5.00^0C in December-January and very hot in summer with highest of 47.00^0C in May - June. Winter frost and summer hot descicating winds (*Loo*) are also not uncommon in the region. The average monthly rainfall in this area is above 90.00 cm concentrated during the monsoon months *ie*. July to September with a few occasional showers during the winter months.

TABLE 1: Weekly meteorological observation during crop season

Month	Weeks	Temperature ^0C		Relative Humidity %		Sun Shine Hour	Rain Fall (mm)
		Maximum	Minimum	Maximum	Minimum		
Meteorological observations for the second year (98 - 99)							
JUNE 98	1st week	45.84	30.22	43.28	12.14	13.40	Nil
	2nd week	43.10	32.57	51.85	22.71	13.42	1.71
	3rd week	38.84	28.77	82.85	47.75	13.43	0.85
	4th week	38.22	29.28	82.71	47.71	13.44	1.94
JULY 98	1st week	33.77	27.22	91.42	63.71	13.43	7.74
	2nd week	33.79	27.13	93.41	63.22	13.43	2.18
	3rd week	32.50	25.32	98.14	70.00	13.33	3.90
	4th week	35.71	27.61	89.00	38.00	13.27	Nil
AUGUST 98	1st week	33.70	26.11	95.42	76.71	13.27	7.18
	2nd week	33.80	27.07	95.28	76.00	13.09	14.40
	3rd week	33.45	27.31	91.28	76.71	13.00	1.08
	4th week	33.87	26.25	96.57	63.14	12.89	11.60
SEPTEMBER 98	1st week	33.25	26.08	96.42	54.57	13.16	14.37
	2nd week	32.34	25.34	96.85	46.14	13.04	12.45
	3rd week	34.68	26.42	95.85	52..00	12.54	4.48
	4th week	35.02	26.12	92.57	55.00	12.02	1.00
OCTOBER 98	1st week	34.30	26.37	94.14	28.00	12.37	Nil
	2nd week	35.61	26.85	95.00	28.42	12.18	Nil
	3rd week	33.05	25.00	94.28	27.14	11.29	Nil
	4th week	33.37	21.71	92.85	22.28	11.19	Nil
NOVEMBER 98	1st week	33.25	21.29	92.95	15.48	11.25	Nil
	2nd week	30.15	18.37	93.71	14.28	11.38	Nil
	3rd week	26.85	18.02	96.00	11.85	11.30	1.50
	4th week	26.98	13.47	93.00	16.14	11.24	Nil
DESEMBER 98	1st week	27.14	9.28	88.85	62.67	11.17	Nil
	2nd week	26.80	9.41	92.42	58.57	11.15	Nil
	3rd week	22.92	8.37	99.28	72.56	11.12	Nil
	4th week	20.20	7.27	100.0	76.96	11.13	Nil
JANUARY 99	1st week	22.12	8.00	98.42	27.28	11.15	Nil
	2nd week	19.77	7.65	100.0	58.71	11.19	Nil
	3rd week	15.62	4.11	100.0	75.00	11.25	Nil
	4th week	27.11	9.32	94.71	28.55	11.33	Nil
FEBUARY 99	1st week	19.68	8.60	94.85	37.14	11.37	0.50
	2nd week	26.04	11.94	94.28	42.00	11.49	Nil
	3rd week	29.70	14.02	93.28	30.42	11.52	Nil
	4th week	30.91	16.07	81.71	21.14	12.13	Nil
MARCH 99	1st week	32.08	13.05	91.71	21.71	12.23	Nil
	2nd week	33.18	16.27	85.71	22.00	12.33	Nil
	3rd week	33.57	14.45	78.85	19.57	12.37	Nil
	4th week	36.14	16.25	40.57	17.57	12.41	Nil
APRIL 99	1st week	40.97	20.48	32.07	11.14	12.48	Nil
	2nd week	40.74	23.17	45.98	13.57	13.21	Nil

	3rd week	40.82	20.11	39.35	12.57	13.29	Nil
	4th week	44.17	24.55	25.71	5.42	13.31	Nil
Meteorological observations for the second year (99–2000)							
JUNE 99	1st week	41.60	24.87	29.42	10.00	13.41	Nil
	2nd week	40.47	26.70	60.21	22.85	13.42	Nil
	3rd week	36.98	27.92	76.14	41.14	13.43	Nil
	4th week	35.27	26.51	75.14	44.42	13.44	1.30
JULY 99	1st week	47.42	27.91	71.57	37.00	13.41	Nil
	2nd week	35.30	29.04	86.85	58.42	13.39	29.52
	3rd week	33.88	27.71	93.28	67.71	13.33	9.85
	4th week	32.61	25.42	92.85	71.28	13.28	10.42
AUGUST 99	1st week	33.87	26.81	87.21	61.71	13.15	1.17
	2nd week	30.87	25.98	96.57	77.00	13.07	6.45
	3rd week	31.08	24.80	98.57	60.42	13.37	40.47
	4th week	34.10	25.05	94.14	65.57	13.21	1.11
SEPTEMBER99	1st week	31.40	25.61	100.0	79.71	13.15	12.02
	2nd week	32.40	24.97	97.14	71.57	13.05	0.92
	3rd week	32.48	25.80	97.8	71.28	12.07	6.14
	4th week	32.31	24.88	95.00	64.42	12.07	1.20
OCTOBER 99	1st week	31.80	23.5	94.7	66.6	12.30	60.6
	2nd week	33.15	23.28	93.28	59.71	12.20	Nil
	3rd week	31.81	21.42	93.21	59.42	11.30	8.0
	4th week	32.94	19.91	95.14	37.42	11.18	Nil
NOVEMBER 99	1st week	33.5	21.12	92.0	39.0	11.02	Nil
	2nd week	31.6	15.90	86.9	28.4	11.38	Nil
	3rd week	29.4	12.90	92.1	43.9	11.30	Nil
	4th week	27.4	12.04	92.0	31.0	12.23	Nil
DESEMBER 99	1st week	26.6	11.5	96.4	35.7	11.16	Nil
	2nd week	24.4	10.1	96.7	46.1	11.14	Nil
	3rd week	29.0	8.3	96.9	49.40	11.12	Nil
	4th week	21.40	8.4	100.0	73.5	11.12	Nil
JANUARY 00	1st week	15.5	6.9	99.6	77.4	11.15	Nil
	2nd week	24.3	10.4	96.4	54.7	11.19	2.0
	3rd week	24.1	9.5	90.1	34.7	11.26	Nil
	4th week	25.1	9.6	93.2	38.4	11.39	8.0
FEBUARY 00	1st week	25.4	12.6	94.4	41.4	11.04	Nil
	2nd week	23.8	7.7	95.0	35.4	11.14	Nil
	3rd week	26.7	8.6	88.4	27.9	11.28	Nil
	4th week	28.1	9.2	85.5	20.0	11.74	Nil
MARCH 00	1st week	32.7	15.5	80.4	23.7	11.84	Nil
	2nd week	32.4	14.5	79.3	23.0	12.35	Nil
	3rd week	33.2	14.7	72.6	14.8	12.06	Nil
	4th week	34.9	16.6	77.7	28.9	12.47	Nil
APRIL 00	1st week	39.1	18.9	60.6	12.3	13.11	Nil
	2nd week	41.2	17.4	60.4	11.3	13.21	Nil
	3rd week	40.1	24.5	69.4	18.9	13.30	Nil
	4th week	41.0	25.0	69.4	20.1	13.31	Nil

WEATHER CONDITIONS DURING CROP SEASON :

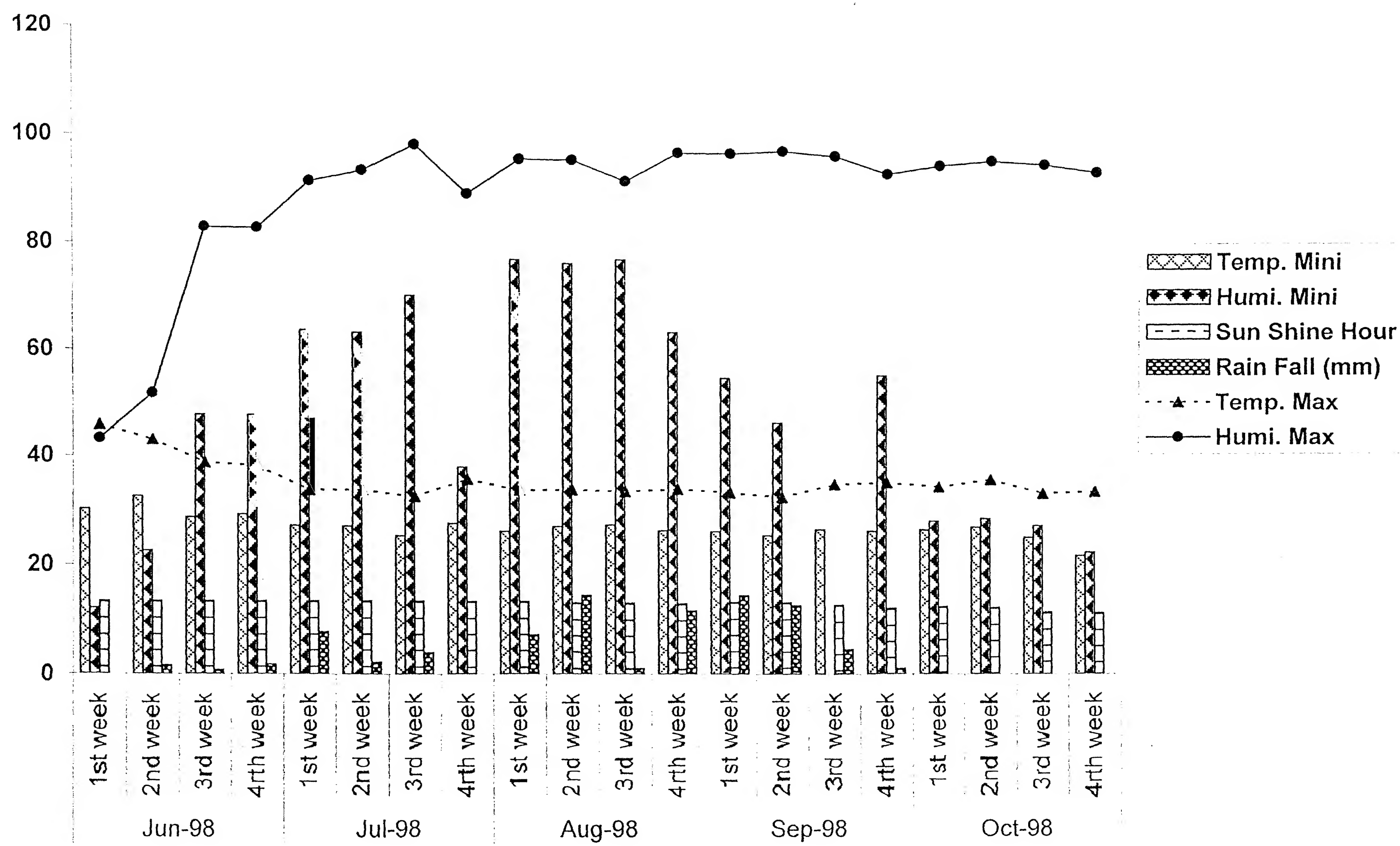
The weekly meteorological data on maximum and minimum temperature, relative humidity, rainfall and sunshine duration (hr/day) prevailed during the period of experimentation are recorded from the meteorological observatory located at, Agronomy research farm, college of Agriculture, A.A.I.-D.U. Allahabad. The values of monthly meteorological parameters are depicted through figure.

Both maximum and minimum temperature relative humidity and sunshine hours were almost identical to normal values of these parameters at the locality. But rainfall was concentrated during July and August with heavy rainfall in August after which rainfall was quite low, because of low rainfall rice crop was irrigated as and when required. Maximum temperature was also relatively higher than average conditions during initial growth stage of wheat, which resulted in to poor growth of wheat crop. Later both maximum and minimum temperatures again shooted up in the month of March, which resulted into forced maturity of wheat. As a whole, the weather conditions prevailed during the crop season were almost normal for cultivation of both rice and wheat crops.

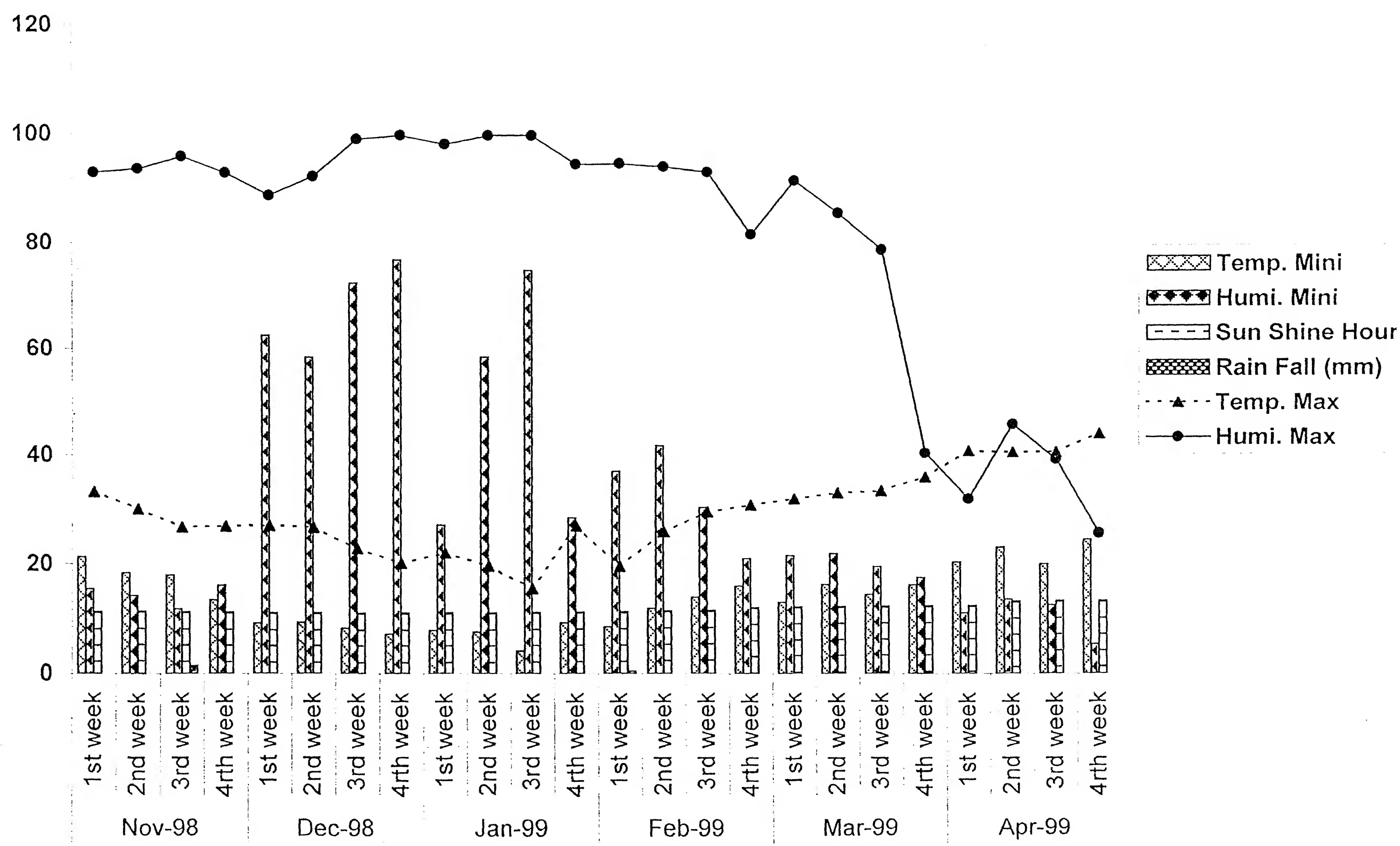
SOIL:

The soil of Allahabad region is Alluvial with moderate water holding capacity. To determine the characteristics of soil, five soil samples were taken with the help of soil augar from different spots of entire experimental field from 0-20 cm depth before using the land under present investigation. After this, a composite soil sample was prepared. Composite samples was analysed in the laboratory for different

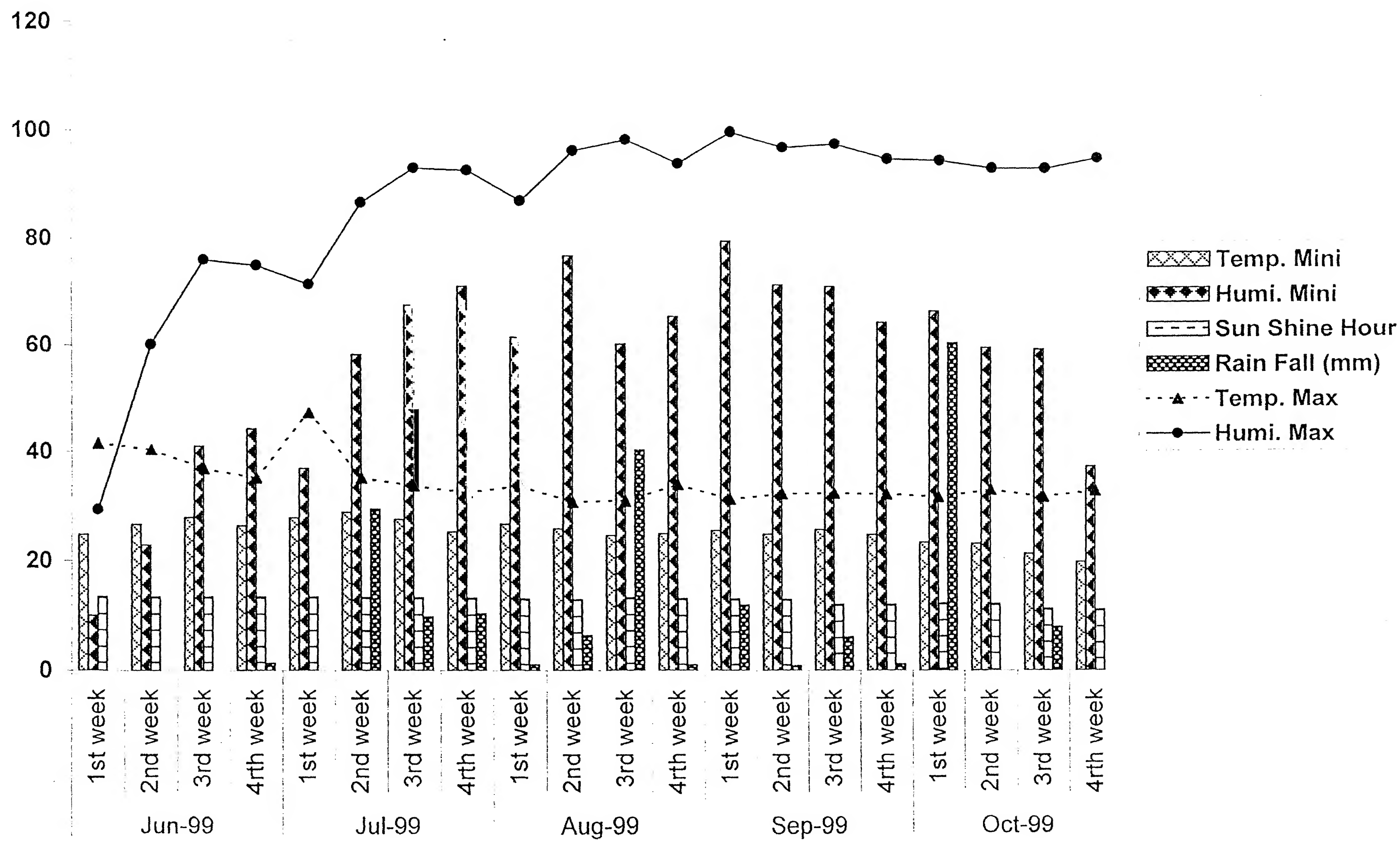
Meteorological observation during crop season (June98-Oct-98)



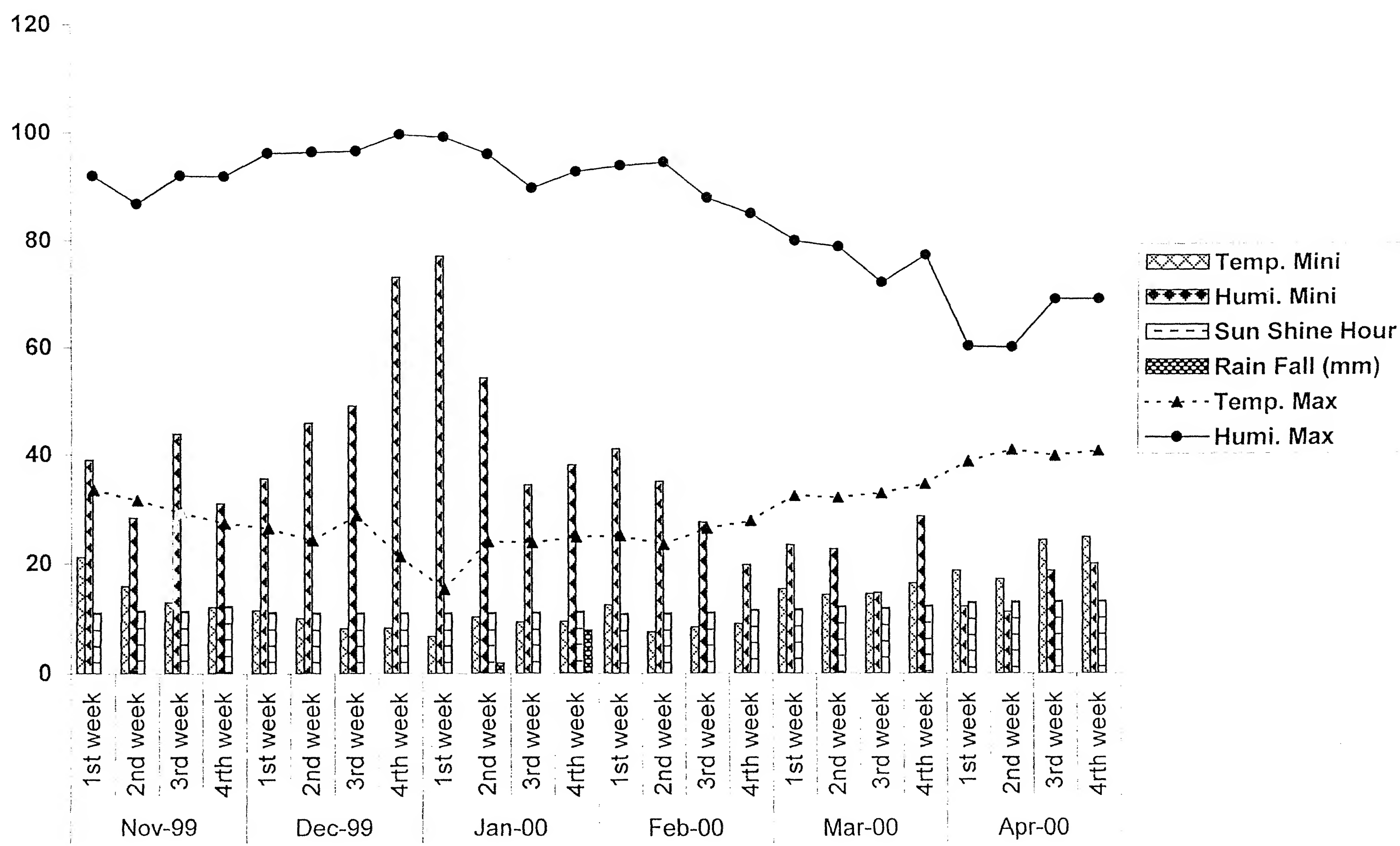
Meteorological observation during crop season (Nov98-Apr99)



Meteorological observation during crop season (Jun99-Oct99)



Meteorological observation during crop season (Nov98-Apr00)



CROPPING HISTORY OF THE FIELD:

The cropping history of the experimental field during last few years is given in the following Table 3:-

TABLE 3: Cropping history of the field during previous years

CROP			FERTILIZER (kg/ha)					
YEAR	*KHARIF*	*RABI*	*KHARIF*			*RABI*		
			N	P	K	N	P	K
1994-1995	RICE	WHEAT	120	60	40	100	50	30
1995-1996	RICE	WHEAT	120	60	40	100	50	30
1996-1997	RICE	WHEAT	120	60	40	100	50	30
1997-1998	RICE	WHEAT	120	60	40	120	60	40
1998-1999	PRESENT EXPERIMENT		120	60	40	120	60	40
1999-2000	PRESENT EXPERIMENT		120	60	40	120	60	40

It is clear from the information given in above Table that a rice-wheat cropping system was continuously followed in the experimental field with an uniform dose of fertilizer application. Thus, it could be said that the fertility status of the field was homogenous prior to utilization of land under present experimentation.

LAND PREPRA TION :

Under present experiment rice crop was grown by transplanting of seedlings on puddled field. The field was tilled twice with the help of tractor tyne cultivator. After this, land was puddled twice with the help of tractor driven puddler. For puddling, rainwater was impounded in the field with the support of bund provided all around each plots. After puddling, the field was levelled just one day before transplanting seedlings. In case of transplanted

rice, nursery beds were prepared to raise the seedlings. A piece of 1000 m^2 area was prepared by tilling the land with the cultivator followed by two harrowing with disc harrow and later the field was puddled. After this, four nursery beds of 20m×1.5m×0.15 m were prepared by leaving 0.50 m distance between two beds. Certified seeds treated with cereson + streptocycline was sown on nursery beds separately in standing water. Nursery beds were manured with l0t FYM + 50 kg N + 6.0 kg P_2O_5 + 40 kg K_2O/ha as per area of nursery beds. Top dressing of 50 kg N/ha (area basis) was done on 15th day of sowing. In case of wheat, field was prepared by one ploughing followed by harrowing and planking. Finally experimental field was levelled with the help of leveller.

LAY OUT:

The treatments were laid out on well prepared seed bed in factorial randomized block design with four replication as per the layout plan given in Figure -1.

The details of the treatments are given below:

(A) **SOURCE OF NITROGEN**

(i) Ammonium Sulphale (AS)

(ii) Ammonium Chloried (Acl)

(iii) Calcium Ammonium Nitrate (CAN)

(iv) Urea (U).

(B) **SOURCE OF PHOSPHORUS**

(i) Diammonium Phosphate (DAP)

(ii) Single Super Phosphate (SSP)

(iii) Nitrophos (NP)

TREATMENT COMBINATIONS (4 x 3)

(i) AS x DAP

(ii) AS x SSP

(iii) AS x NP

(iv) ACl x DAP

(v) ACl x SSP

(vi) ACl x NP

(vii) CAN x DAP

(viii) CAN x SSP

(ix) CAN x NP

(x) U x DAP

(xi) U x SSP

(xii) U x NP

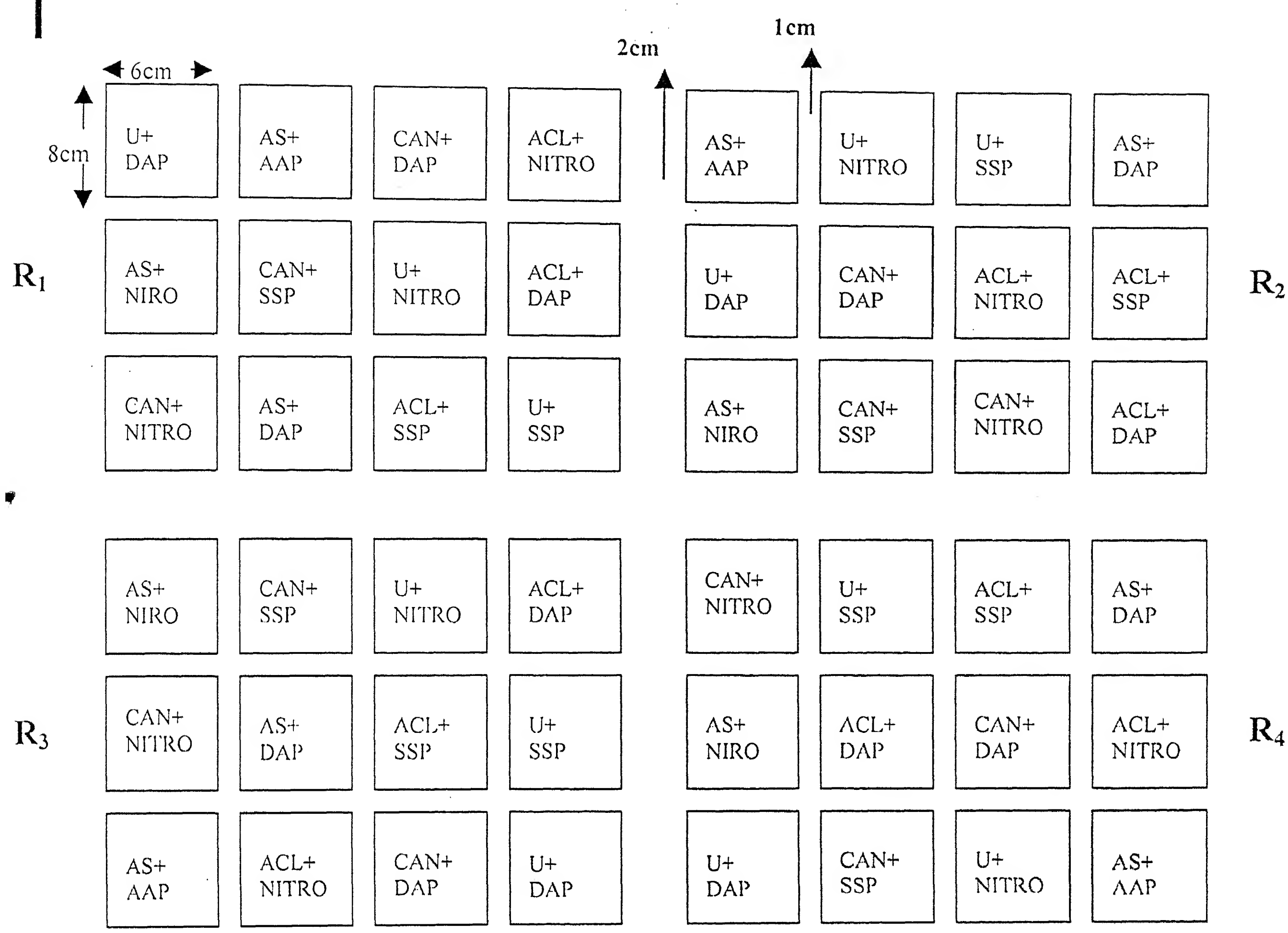
OTHER DETAILS OF EXPERIMENT

Gross plot size	– 6.00 m x 8.00 m
Net plot size	– 5.40 m x 7.20 m
Distance between plots	– 1.0 m
Distance between replication	– 2.00 cm
Distance between Rows	– 0.20 m

SOWING/TRANSPLANTING :

Rice nursery was irrigated before uprooting the seedlings. On the day of transplanting rice seedlings were uprooted in morning and transported to the main field, which was already puddled and levelled. Transplanting of one month old seedlings was done by using two seedlings/hill at a spacing of 20.00 x 15.00 cm.

Layout of plot



U	=	Urea
AS	=	Ammonium Sulphate
CAN	=	Calcium Ammonium Nitrate
ACL	=	Ammonium Chloride
DAP	=	Diammonium Phosphate
SSP	=	Single Supper Phosphate
NITRO	=	Nitrophos

Gap filling was done on 10th day after transplanting to maintain standard plant population. During *rabi,* after harvesting of rice sowing of rice sowing of certified seeds was done in rows at 20 cm apart. Good germination in first year did not require gap filling, but in second year gap filling was done on 10th day after sowing because of poor germination.

APPLICATION OF FERTILIZER:

Full dose of phosphorus and potash along with 25% nitrogen was applied as basal as per treatments. Remaining nitrogen was top dressed in two equal splits at 20 and 45 days after transplanting. In all cases, top dressing of nitrogen fertilizer was done after completing the weeding operation in the field. In case of wheat, half quantity of nitrogen and full quantity of phosphorus and potash were applied as basal as per treatments. Remaining nitrogen was top-dressed in two equal splits just after sixth day of first and second irrigation respectively.

IRRIGATION:

The rainfall was uneven with long dry spells during *kharif* season, hence rice was irrigated as and when required to maintain 5.0 to 10.0 ± cm water level in the field at early and advanced growth stages. In case of wheat a pre-sowing irrigation was given for better germination. There after, wheat crop was irrigated at regular interval of 20 days, starting from 20 days after sowing.

WEED CONTROL:

Both the crops were severely infested with a large number of weeds but intensity of weed was somewhat less in case of transplanted rice. *Echinochloa crusgall.* L., *Echinochloa colonum* L., *Monochoria*

vegenalis L. and *Commelina benghalensis* L. were the dominating weeds in rice crop. Pre emergence application of Butachlor @ 21.50 kg ai/ha was done on second day after transplanting in standing water. This was followed by hand weeding at 30 days after transplanting. *Phalaris minar* Retz, *Medicago indica* and *Chenopodium album* L. were the dominant weeds in wheat crop. Post emergence application of Isoproturon @ 1.00 kg ai + 2,4-D 0.50 @ kg ai/ha was done uniformly at 25th day after sowing of wheat. No hand weeding was required due to efficient control of weeds by herbicidal mixture.

PLANT PROTECTION MEASURES :

Damage by stem borer (*Scirpophago incertulas*) was observed in early growth stage, which increased slowly upto 60 days after transplantation. But, the infestation was below the economical threshold limit. At maturity stage, the attack of strink bug (*Leptocorisa varicanis*) was noticed but the intensity was negligible. Spraying of monocrotophos 36 EC @ 1000 ml/ha was done uniformly in all plots to control the infestation of this pest. No severe attack of insect pest/disease was observed in wheat crop.

HARVESTING:

Harvesting of physiologically matured rice was done manually with the help sickle as per treatments. Firstly harvesting of crop from border area was done. Two border rows from both sides of each plots and 30 cm area in both ends of all rows were harvested. The harvested produce from border area was removed from the experimental plot by leaving the net plot area intact under each treatment. After this, harvesting of net plot was done treatment wise separately. The harvested produce of each plot

was allowed to sun drying for two days in respective plots. The produce of each plot was tied into bundles and then tagged with luggage labels and finally, weighed on spring balance plot wise. Harvesting of wheat was performed similarly as in case of rice, firstly border areas were harvested in each plot and the produce of all border area was removed from the fields. Then harvesting of net plot was done separately for each plot. Harvested produce was tied into bundles (plot wise) and weighed on spring balance before transporting to the threshing floor.

THRESHING AND WINNOWING :

Threshing of rice was done plot wise separately with the help of manually operated pedal thresher. The chaffy grains obtained after threshing from each plot were cleaned manually with the help of hand fan (*Supa*) and cleaned seeds of each plot were weighed on double pan balance separately. But threshing of wheat was done manually by beating with wooden sticks for each plot separately. Then winnowing was done in the same manner as done in case of rice. Finally weight of cleaned grain was recorded plot wise on double pan balance.

SAMPLING TECHNIQUE :

One meter row length in five rows of wheat was marked randomly with the help of wooden sticks and tagged with for recording the various observations pertaining to different growth parameters at successive growth stages and then yield attributes at maturity. In case of rice five hills were randomly selected to record the observations of growth parameters and yield attributes at different growth stages.

OBSERVATIONS RECORDED :

PLANT POPULATION :

The plant population was maintained in each plot by thinning of extra plants or reseeding/transplanting in gaps, as required.

MORPHOLOGICAL PARAMETERS :

Plant height and tiller counts were recorded at 30,60, 90 DAT/DAS and finally at harvest of crop..

PLANT HEIGHT :

This study was made in both, rice and wheat crop. The height of five marked plants was measured on the main culm from the ground level to the base of well emerged last leaf with the help of meter scale at different growth stages including at maturity and mean height was computed.

NUMBER OF TILLERS/m^2 :

The total number of tillers from the five randomly selected hills was counted in case of rice crop. Tiller count in wheat was recorded in five selected rows and mean values were computed from each treatment for all observations. Finally, the values were converted into value per square meter.

YIELD ATTRIBUTING CHARACTERS ;

EFFECTIVE TILLERS/m^2:

The total number of ear bearing (effective) tillers from five randomly selected hills in rice and from five selected rows in wheat was counted for each plot and mean was computed for all treatments in case of both crops. Finally, mean values were converted into value per square meter area.

LENGTH OF EARHEAD :

Ten ear heads were selected randomly from each plot at the time of harvesting of both crop components. The length of each ear head was measured from its base to the tip, mean values were determined for each treatment.

NUMBER OF GRAINS/EARHEAD :

Grains from each of the five selected ear heads were removed plot wise separately. After this, healthy and chaffy grains were separated for each sample in rice, but in case of wheat only healthy seeds were separated. The counting of healthy and chaffy grains was done and then mean was worked out.

TEST WEIGHT:

Grains were collected from the grain produced from each plot and 1000 seeds were counted from each sample in case of both rice and wheat crops. These seeds were weighed on electronic balance and the values were reported as test weight.

HARVEST INDEX :

The harvest index or sink coefficient is the ratio of grain yield to biological yield (grain yield + straw yield) and it is expressed in percentage. It was calculated as per the formula proposed by Nichiporovich (1967) under each treatment for both crops.

$$\textit{Harvest Index (\%)} : \frac{\text{Economical Yield (Grain Yield)}}{\text{Biological Yield (Total biomass Prodused)}} \text{ X } 100$$

PROTEIN CONTENT :

The protein content of grains were chemically analysed. For this the oven dried samples, treatmentwise homogenus samples were prepared after grinding the grains for both the crops. One gram oven dried sample from each treatment was analysed for nitrogen content by Micro Kjeldahl's method (Chappman and Pratt, 1961). Then crude protein content was worked out by multiplying the nitrogen content by 6.25.

GRAIN YIELD :

Weight of grains per plot was recorded under each treatment for both crop and it was converted into grain yield per hectare separately.

STRAW YIELD :

Weight of straw per plot under each treatment for both crops was determined by subtracting the weight of grains per plot from the weight of biological produce of corresponding plots. After this, values of each plot were converted into straw yield per hectare.

ECONOMICS OF TREATMENTS :

For this purpose, gross monetary return (GMR) as value of produce and total cost of cultivation per hectare was determined for both crops separately under each treatment. Existing market price of inputs used and out put obtained under each treatment was taken into consideration to calculate these values. Then the net monetary return (NMR) for each plot was computed by deducting the cost of cultivation from the value of produce under a particular treatment. The benefit cost ratio (profitability) under each treatment was also worked out by using the following formula:

$$\textit{Benefit cost ratio :-} \quad \frac{\textit{Gross monetary return}}{\textit{Cost of cultivation}}$$

STATISTICAL ANALYSIS :

The data obtained on various observations were tabulated and then subjected to their statistical analysis as per method of analysis of variance suggested by Panse and Sukhatme (1976). The influence of treatments was tested with F-test and wherever F-test shows its significance, the difference between the treatments was further compared with critical difference at 5% and 1 % level of probability. The procedure for analysis of variance to analyse various data are given in Table below :-

TABLE 4: Details of analysis of variance for the experiment

Source of Variance	D.F.	S.S.	M.S.	F (cal)	F(tab)
Replication	2				
Nitrogen (N)	3				
Phosphorus (P)	2				
Interaction (N X P)	6				
Error	22				
Total	35				

CHAPTER- IV

RESULT AND DISCUSSION

RESULT AND DISCUSSION

Data recorded on various observations during present investigation were tabulated and subjected to statistical analysis. Results of important values interpreted along with related tables in this chapter. The most important results also depicted through figures.

GROWTH PARAMETERS OF RICE:

PLANT HEIGHT:

Data pertaining to plant height of rice at successive growth stages including maturity stage as affected by different treatments are given in table number 5 and graphically represented in the figure 2 and 3.

It is clear from the data that plant height gradually increased under treatments up to 90 DA T and a little reduction in plant height was observed under all treatments. Different nitrogen sources produced significant difference in plant height. Taller plants were produced by ammoniacal form of nitrogenous sources (i.e ammonium chloride and ammonium sulphate) as comparison to calcium ammonium nitrate and urea. Plant height produced by AS and ACI was statistically at par. Reduction in losses of nitrogen, applied through ammoniacal form (i.e. AS & ACI) improved the fertilizer use efficiency (FUE) of crop. This may be the reason of taller plants under ammoniacal source of nitrogen (Raghavatu *et al.*, 1975)

The effect of phosphatic sources on plant height was significant at all growth stages including maturity. Nitrophos produced tallest plants among all phosphatic sources while single super phosphate produced dwarfest rice plants. Height of rice plants under nitrophos and diammonium phosphate treatment was at par. Presence of additional available nitrogen in nitrophos and diammonium phosphate treatment may

Table 5: Plant height of Rice as affected by different sources of nitrogenous and phosphatic fertilizer during first year

Source	30 DAT				60 DAT				90 DAT				At Harvest			
Phosphorus / Nitrogen	SSP	DAP	NP	AV	SSP	DAP	NP	AV	SSP	DAP	NP	AV	SSP	DAP	NP	AV
Urea	28.20	31.80	38.30	**32.80**	46.30	49.90	57.10	**15.10**	74.30	77.20	85.00	**78.80**	73.70	76.00	84.50	**78.1**
AS	31.50	42.40	39.80	**37.90**	49.40	60.80	58.50	**56.20**	76.50	88.40	86.60	**83.90**	75.30	87.30	85.80	**82.8**
CAN	30.00	35.90	36.90	**34.40**	46.40	53.70	55.10	**51.80**	73.70	81.20	82.70	**79.20**	76.20	79.90	81.80	**79.3**
Acl	33.10	41.30	40.60	**38.30**	50.00	60.00	58.60	**56.20**	77.60	88.30	86.50	**84.10**	76.00	87.70	85.70	**83.1**
AV	**30.70**	**37.90**	**38.90**		**47.90**	**56.10**	**57.30**		**75.50**	**83.80**	**85.20**		**75.30**	**82.70**	**84.50**	
CD For	N	P	NxP		N	P	NxP		N	P	NxP		N	P	NxP	
At 5%	3.17	2.75	NS		3.91	3.39	NS		4.11	3.56	NS		3.66	3.17	NS	
At 1%	4.31	3.74	NS		5.32	4.61	NS		4.58	4.83	NS		4.98	4.31	NS	

Fig. 2: Plant height of Rice as affected by different treartments during first year

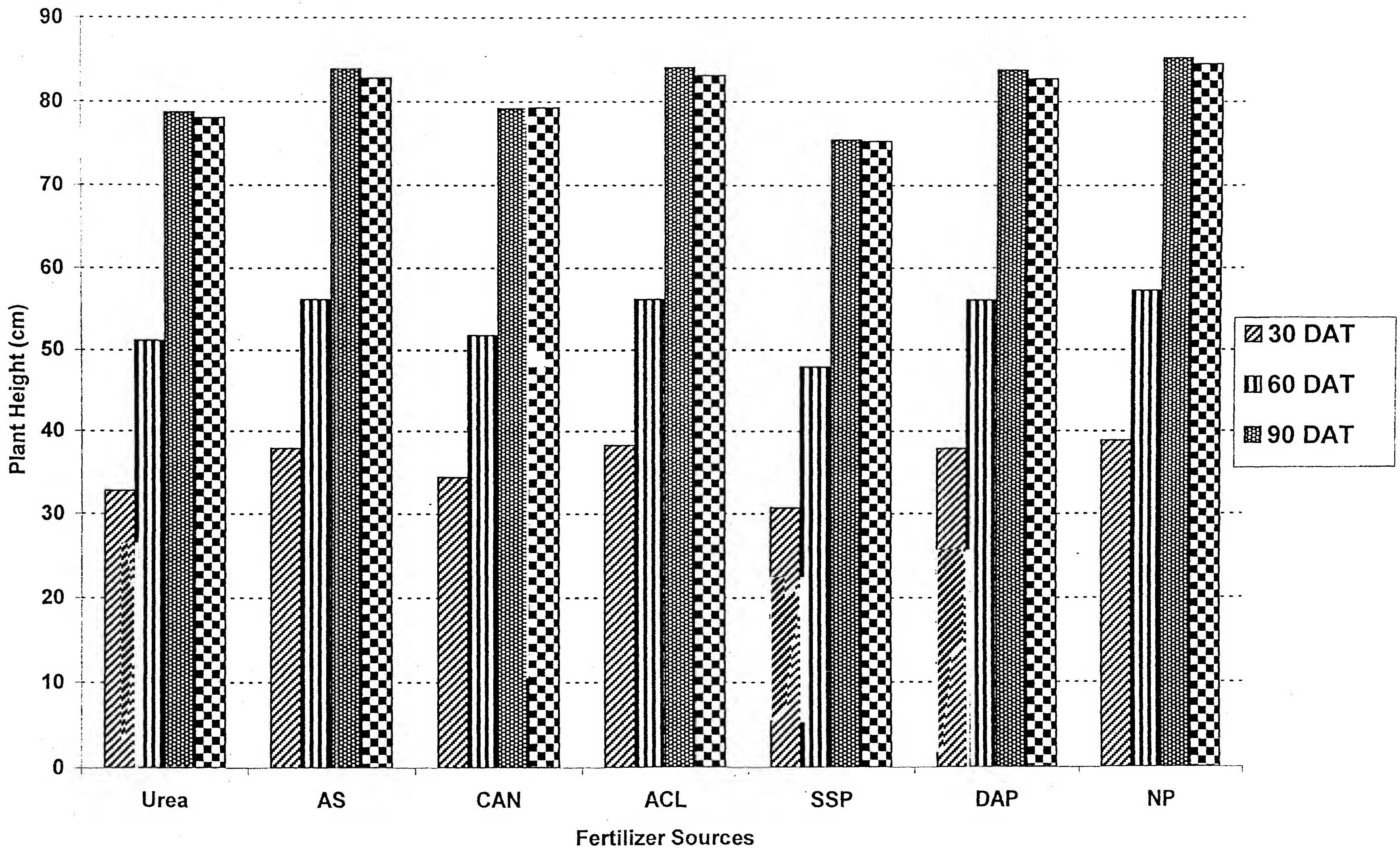
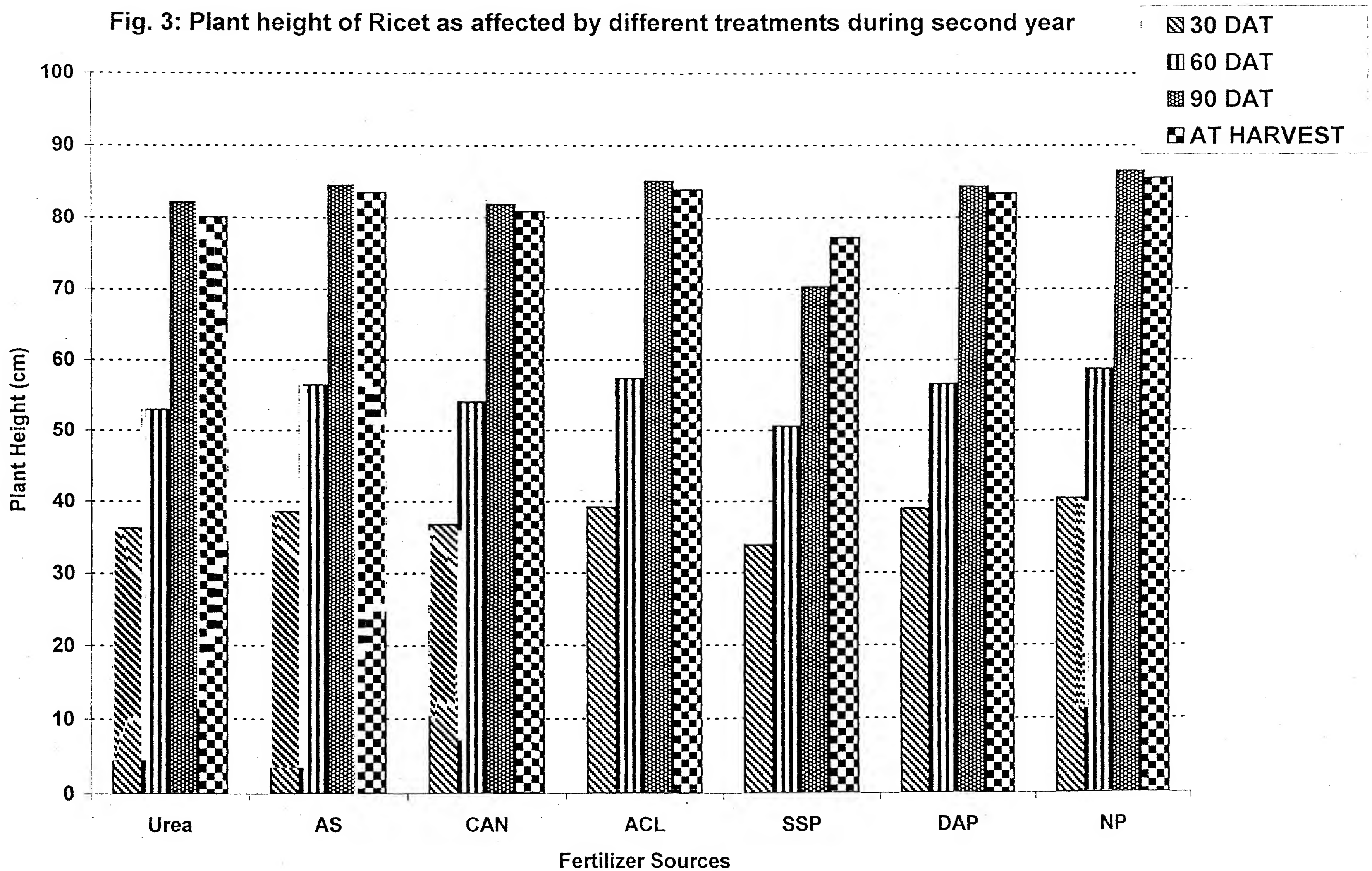


Table 6: Plant height of Rice as affected by different sources of nitrogenous and phosphatic fertilizer during second year

Source	30 DAT				60 DAT				90 DAT				At Harvest			
Phosphorus / Nitrogen	SSP	DAP	NP	AV	SSP	DAP	NP	AV	SSP	DAP	NP	AV	SSP	DAP	NP	AV
Urea	30.00	39.00	40.00	**36.30**	44.90	56.60	58.00	**53.00**	72.30	84.40	86.40	**82.10**	71.40	83.30	85.60	**80.10**
AS	32.60	40.90	42.30	**38.60**	49.60	60.00	59.90	**56.50**	77.40	87.70	88.30	**84.50**	76.30	86.80	87.30	**83.50**
CAN	39.20	33.90	37.40	**36.80**	56.80	50.40	55.30	**54.11**	85.00	78.20	82.30	**81.80**	83.80	77.20	81.40	**80.80**
Acl	33.70	41.80	42.00	**39.20**	51.00	59.40	61.70	**57.40**	78.70	87.40	89.10	**85.10**	77.40	86.40	87.80	**83.90**
AV	**33.90**	**38.90**	**40.40**		**50.60**	**56.60**	**58.70**		**78.30**	**84.40**	**86.50**		**77.20**	**83.40**	**85.50**	
CD For	N	P	NxP		N	P	NxP		N	P	NxP		N	P	NxP	
At 5%	3.22	2.79	NS		4.18	3.62	NS		4.34	3.76	NS		4.33	3.75	NS	
At 1%	4.38	3.79	NS		5.68	4.92	NS		5.89	5.10	NS		5.88	5.09	NS	

Fig. 3: Plant height of Ricet as affected by different treatments during second year



be the reason for taller plants of rice under this treatment. (Tiwari 1965, Malik and Das, 1965).

The interaction effect of nitrogen and phosphorus on plant height of rice was not significant at all growth stages including maturity. Similar results were observed in second year of experiment, which confirms the findings of previous year.

TILLER COUNT (m^{-2}):

Data concerning number of tiller/m^2 at different growth stages of rice as influenced by different treatments are given in table 7 & 8 and illustrated through figure 4 and 5.

Number of tillers per meter square area was significantly influenced by different sources of nitrogen. Ammonium chloride produced highest number of tillers in both years at all growth stages including maturity. This was closely followed by treatment having nitrogen source as ammonium sulphate while urea and calcium ammonium nitrate produced less number of tillers per meter area as compaired to other sources of nitrogen, this difference was not significant. Improved fertilizer use efficiency under ammoniacal form of nitrogen source lead to rapid vegetative growth of rice plants which resulted in to higher number of tillers per unit area (Maldeniga and Theababu 1977; Mishra and Singh 1968).

Amongst phosphatic sources, diammonium phosphate produced maximum number of tillers followed by single super phosphate. The tiller count was minimum under the nitrophos treatment. All the three sources of phosphorus produced significantly different tiller count at 5% and 1% level of significance at all growth stages of rice plant. The interaction effect was not significant at all stages of plant growth. In second year similar observations were recorded, which confirms the findings of previous year.

Table 7: Tiller count of Rice as affected by different sources of nitrogenous and phosphatic fertilizer during first year

Source	30 DAT				60 DAT				90 DAT				At Harvest			
Phosphorus / Nitrogen	SSP	DAP	NP	AV	SSP	DAP	NP	AV	SSP	DAP	NP	AV	SSP	DAP	NP	AV
Urea	285.0	299.7	275.0	**286.6**	568.5	600.0	559.0	**575.9**	960.0	936.0	834.00	**910.0**	569.0	557.0	479.0	**535.6**
AS	298.0	297.3	274.0	**289.8**	583.5	607.0	534.0	**574.9**	972.0	984.0	852.0	**936.0**	575.0	584.5	534.0	**564.5**
CAN	285.0	287.6	272.0	**281.6**	574.5	578.0	539.5	**564.0**	936.0	912.0	864.0	**904.0**	545.0	527.5	546.5	**539.7**
ACl	389.3	307.0	281.0	**292.4**	597.5	591.0	553.5	**580.7**	948.0	1092.0	870.0	**970.0**	558.5	659.0	512.0	**576.5**
AV	**289.3**	**297.9**	**275.5**		**581.0**	**594.0**	**546.5**		**954.0**	**981.0**	**855.0**		**561.9**	**582.0**	**581.0**	
CD For	N	P	NxP		N	P	NxP		N	P	NxP		N	P	NxP	
At 5%	11.37	9.85	NS		21.58	18.68	NS		42.66	36.95	NS		37.65	32.61	NS	
At 1%	15.46	13.39	NS		29.30	25.39	NS		57.99	50.22	NS		51.18	44.32	NS	

Fig. 4: Tiller count of Rice as affected by different treatment during first year

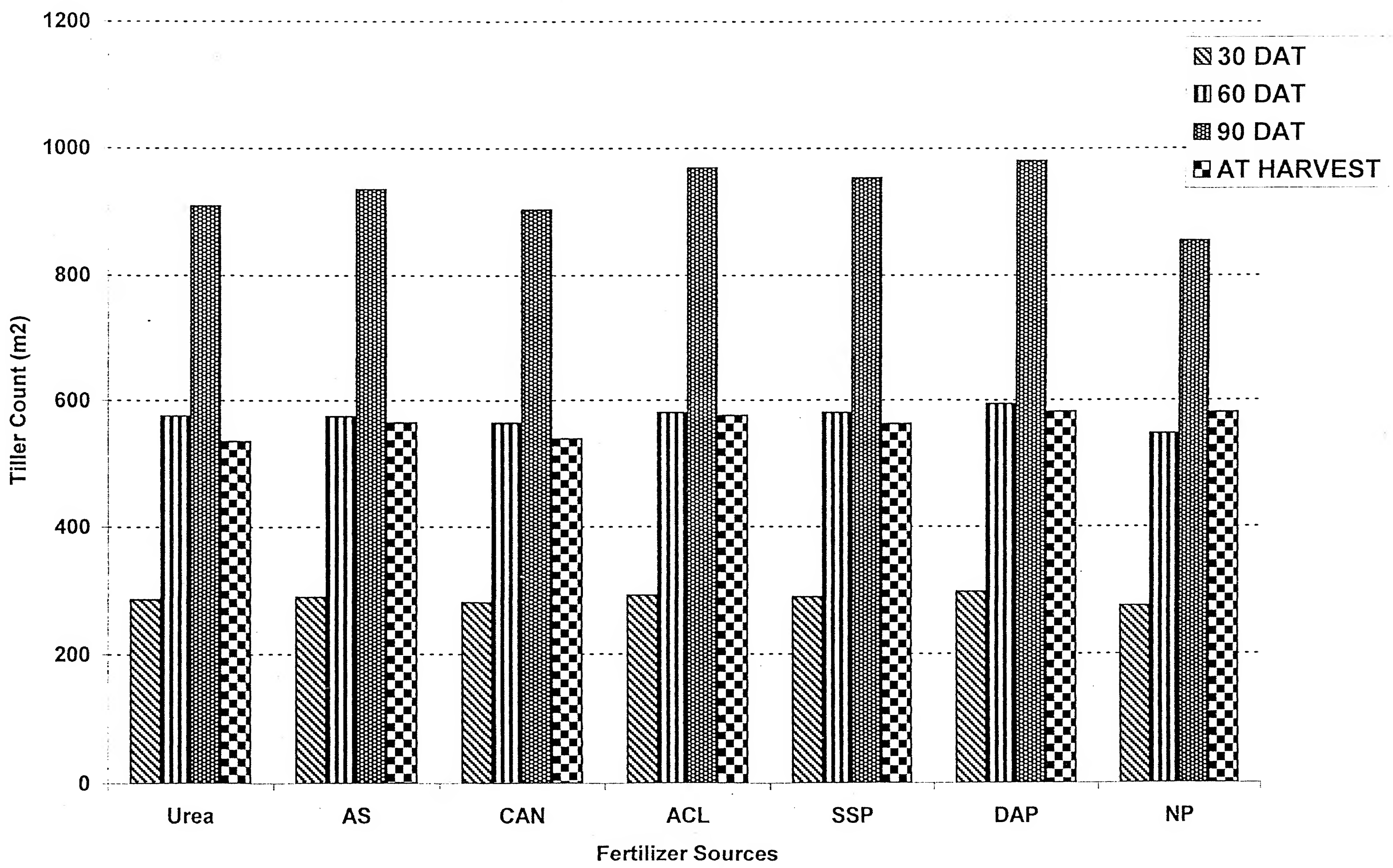
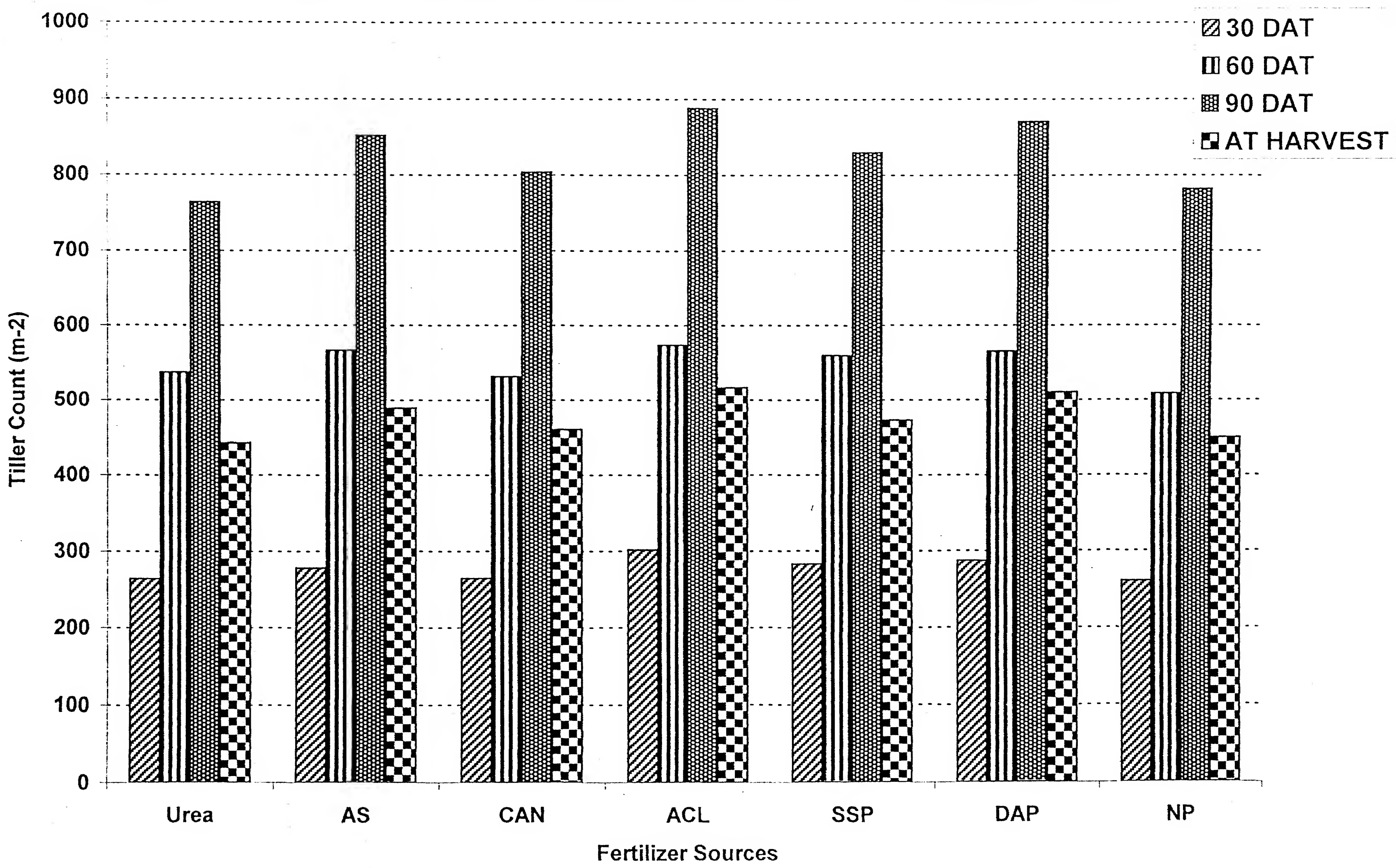


Table 8: Tiller count of Rice as affected by different sources of nitrogenous and phosphatic fertilizer during second year

Source	30 DAT				60 DAT				90 DAT				At Harvest			
Phosphorus / Nitrogen	SSP	DAP	NP	AV	SSP	DAP	NP	AV	SSP	DAP	NP	AV	SSP	DAP	NP	AV
Urea	276.0	273.7	244.3	**264.7**	559.5	541.0	508.5	**537.4**	804.0	768.0	720.0	**764.0**	453.5	462.0	405.0	**443.2**
AS	286.3	274.7	272.3	**277.8**	561.0	582.0	557.5	**566.9**	834.0	876.0	846.0	**852.0**	484.5	503.0	479.5	**489.0**
CAN	264.7	277.3	253.3	**265.1**	551.5	537.0	506.0	**531.5**	840.0	876.0	696.0	**804.0**	476.0	504.5	400.5	**460.3**
Acl	305.3	326.0	275.0	**302.1**	567.0	603.0	551.5	**573.9**	840.0	860.0	864.0	**888.0**	478.0	563.0	512.5	**517.0**
AV	**283.1**	**287.9**	**261.3**		**559.8**	**565.8**	**508.4**		**829.5**	**870.0**	**781.5**		**473.0**	**510.4**	**449.4**	
CD For	N	P	NxP		N	P	NxP		N	P	NxP		N	P	NxP	
At 5%	24.67	21.37	NS		22.33	19.34	NS		25.70	22.30	NS		21.14	18.30	NS	
At 1%	33.54	29.04	NS		30.35	26.29	NS		34.90	30.30	NS		28.73	24.88	NS	

Fig. 5 : Tiller count of Rice as affected by different treatments during second year



YIELD ATTRIBUTING CHARACTERS:

EFFCTIVE TILLERS (m^{-2}):

Data concerning to effective tillers per meter square at different growth stages rice as influenced by different nitrogen and phosphatic sources of fertilizers are in table 9 and 10 and presented in figure 6 and 7.

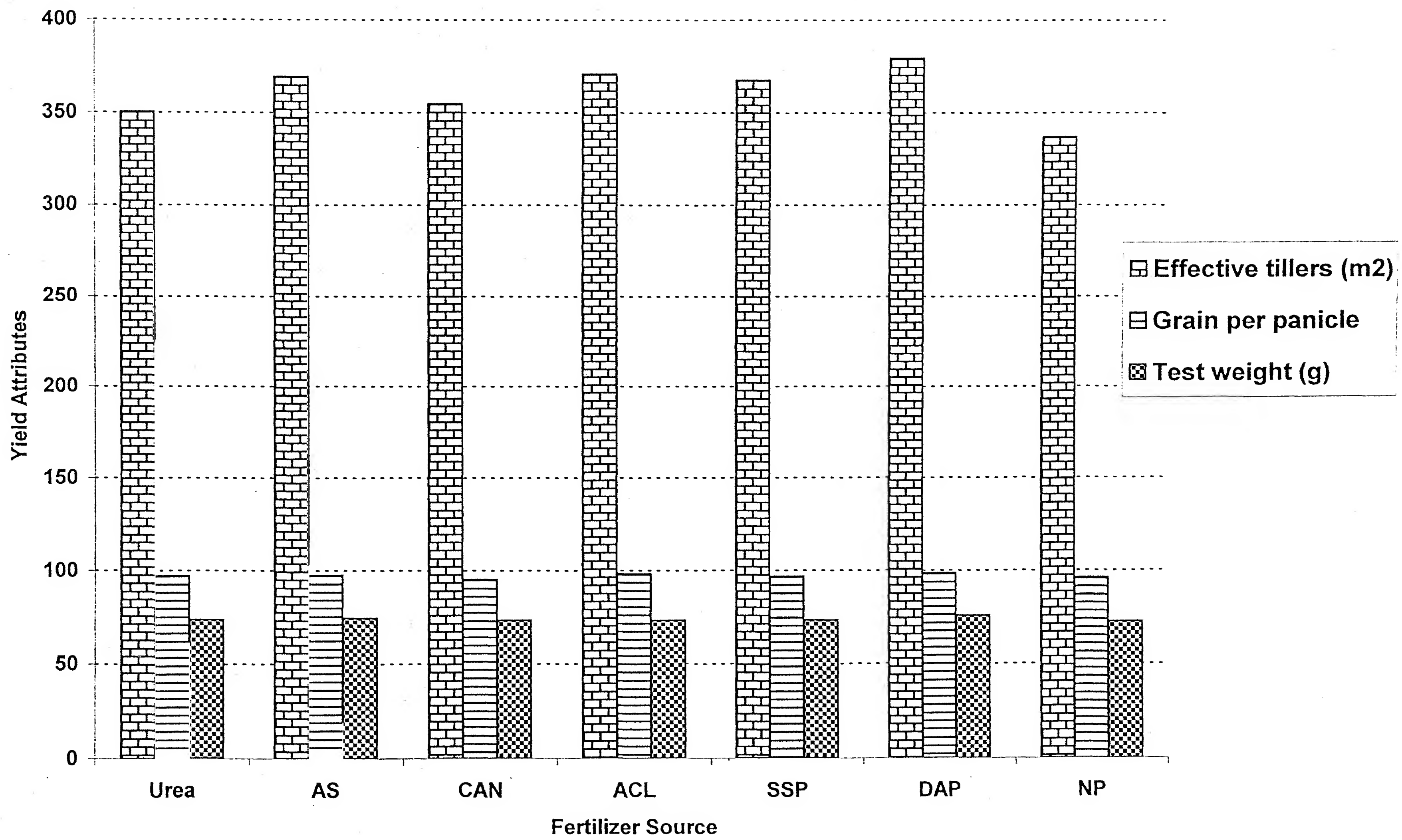
The tiller mortality ranged from 25 to 35% under different treatments but the mortality was somewhat high under phosphatic sources. Rice plants received nitrogen as ammonium chloride produced highest number of effective tillers closely owed by ammonium sulphate, while minimum number of effective tillers was produced under urea followed by calcium ammonium nitrate. In first year the difference was not significant, while in second year this difference was significant at 5% level of significance. Better availability of nitrogen supplied through ammoniacal form may be the reason for higher number of effective tillers under ammonium sulphate and ammonium chloride treatment (Raghavalu and Sreeramamurthy, 1975; Patil and Despande, 1973; Kalyankutty, 1967).

The effective tillers were maximum under the treatment, which received phosphorus through diammonium phosphate, this was followed by single super phosphate. Nitrophos produced minimum number of effective tillers among all phosphorus sources. The difference in number of effective tillers produced by different phosphatic sources is highly significant, but the interaction was not significant. In the second year different phosphatic sources and their interactions with nitrogen produced almost similar results, which confirms the findings of previous year.

Table 9: Yield attributing characters of rice as influenced by different sources of nitrogenous and phosphatic fertilizer during first year

Source	Effective tillers (m^2)				Grain per panicle				Test weight (g)			
Phosphorus / Nitrogen	SSP	DAP	NP	AV	SSP	DAP	NP	AV	SSP	DAP	NP	AV
Urea	372.0	365.0	314.3	**350.4**	98.0	97.0	96.0	**97.3**	74.1	75.9	72.0	**74.0**
AS	374.7	383.3	350.7	**369.6**	98.0	99.0	98.0	**97.6**	76.5	74.7	72.6	**74.6**
CAN	359.0	348.3	357.7	**355.0**	96.0	95.0	95.0	**95.3**	74.1	74.4	72.3	**73.6**
Acl	365.7	418.7	325.7	**371.0**	97.0	103.0	95.0	**98.3**	69.0	77.7	73.5	**73.4**
AV	**367.8**	**379.6**	**337.1**		**96.8**	**98.5**	**96.0**		**73.4**	**75.7**	**72.6**	
CD For	N	P	NxP		N	P	NxP		N	P	NxP	
At 5%	34.53	29.90	NS		0.89	0.77	1.53		NS	NS	NS	
At 1%	46.93	40.64	NS		1.20	1.04	2.08		NS	NS	NS	

Yield attributes of Rice as affected by different treatments during first year



GRAINS PER PANICLE :

In the first year of experiment, it is clear from the table 9 that the effect of nitrogen sources on number of grains per panicle was significantly different at 5% level of significance, whereas this difference was not significant at 1% level of significance. But in second year the difference was significant at 5% and 1% level of significance (Table 10 and figure 7). Among the nitrogenous sources ammonium chloride produced maximum number of grains per panicle followed by ammonium sulphate. But minimum number of grain per panicle was produced by calcium ammonium nitrate in first year and by urea in second year.

Different phosphatic sources showed highly significant effect on number of grains per panicle in both years. Similar results were reported by Bains *et al.* 1970. The interaction effect of nitrogen with phosphorus also produced significant effect on number of grains per panicle, ammonium chloride with diammonium phosphate was the best combination among all, this combination which was closely followed by ammonium sulphate with diammonium phosphate.

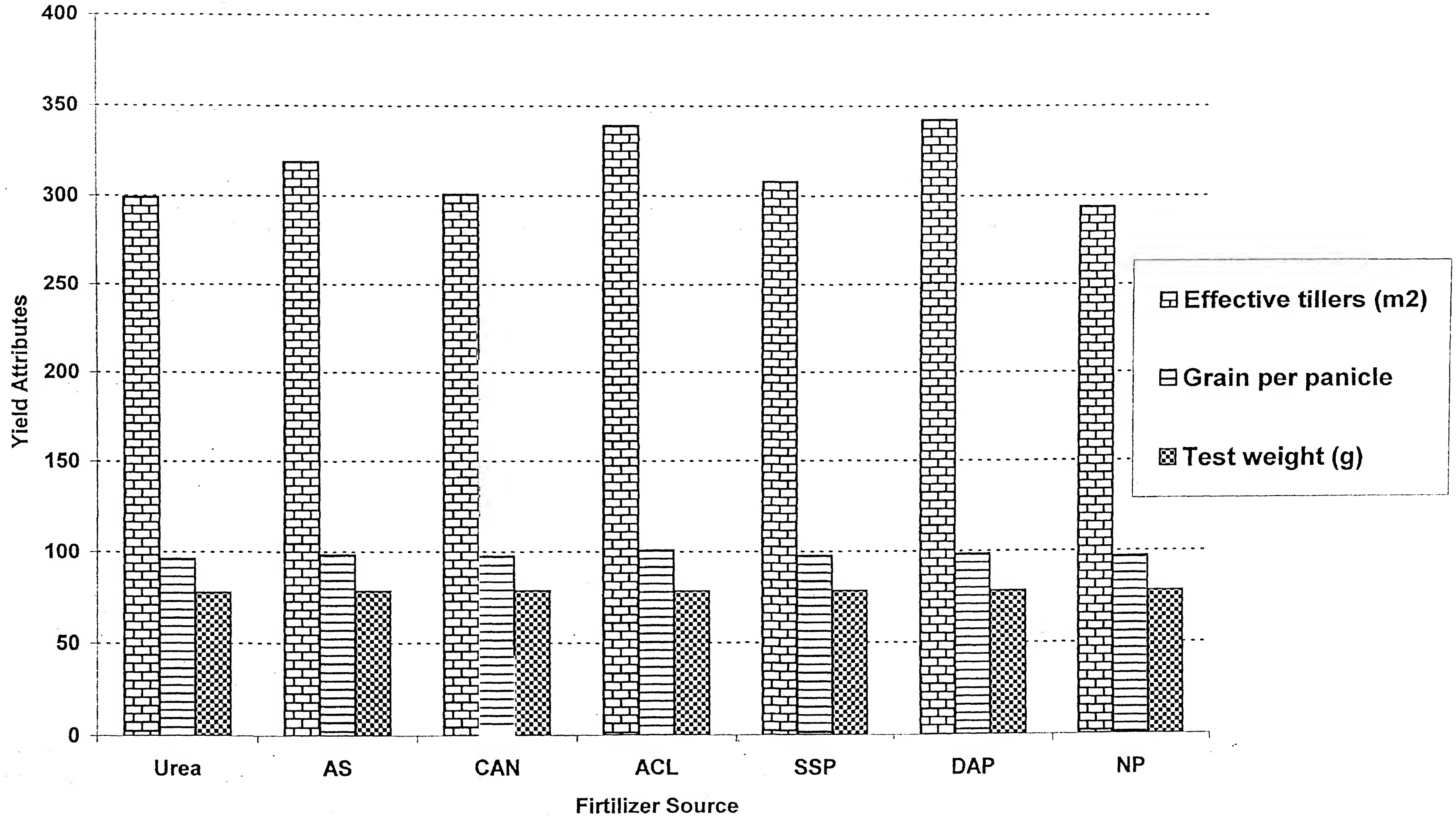
TEST WEIGHT (g) :

This is a varietal character and remained unchanged under different treatments. The effects of different sources of nitrogen, phosphorus and their interaction was not significant, but amongst the nitrogen sources ammonium sulphate produced numerically higher test weight in first year while calcium ammonium nitrate produced higher test weight in second year. Whereas amongst the phosphatic sources diammonium phosphate produced higher test weight in first year and single super phosphate produced higher test weight in second year. Whereas among the phosphatic sources diammonium phosphate produced higher test weight in first year and single super phosphate produced higher test weight in second year. Interaction of nitrogen and phosphorus produced higher test weight under ammonium chloride with

Table 10: Yield attributing characters of rice as influenced by different sources of nitrogenous and phosphatic fertilizer during second year

Source	Effective tillers (m^2)				Grain per panicle				Test weight (g)			
Phosphorus / Nitrogen	SSP	DAP	NP	AV	SSP	DAP	NP	AV	SSP	DAP	NP	AV
Urea	293.3	341.0	263.7	**299.3**	95.6	94.0	94.3	**96.4**	77.4	78.0	78.0	**77.8**
AS	316.0	328.3	263.7	**319.2**	99.3	98.0	98.2	**98.4**	78.9	78.3	78.0	**78.4**
CAN	310.0	329.3	313.3	**301.0**	96.8	97.0	99.1	**97.6**	79.2	78.6	78.0	**78.6**
Acl	312.7	370.3	334.3	**339.1**	99.6	106.0	97.7	**101.1**	78.0	77.7	78.9	**78.2**
AV	**308.0**	**342.3**	**293.8**		**97.8**	**98.8**	**97.3**		**78.4**	**78.2**	**78.2**	
CD For	**N**	**P**	**NP**		**N**	**P**	**NxP**		**N**	**P**	**NxP**	
At 5%	2.71	19.67	NS		1.88	1.63	3.25		NS	NS	NS	
At 1%	30.87	26.74	NS		2.55	2.21	4.42		NS	NS	NS	

Fig. 7: Yield attributes of Rice as affected by different treatments during second year



diammonium phosphate combination in first year, but in second year highest test weight was produced under ammonium chloride with nitrophos.

STRAW YIELD :

Data pertaining to straw yield as affected by different treatments are given in table 11 and depicted in figour 8.

The straw yield of rice differed significantly under different sources of nitrogen, phosphorus and their interactions. Among the different nitrogen sources ammonium chloride produced maximum straw yield followed by ammonium sulphate whereas straw yield was minimum under urea application (Raghavaley *et al.,* 1975). Similarly in second year ammonium chloride produced maximum straw yield (82.5 q/ha), rest of the results for second year was also same as in first year, but the yield of straw was higher in second year than in first year. Suitable environmental condition would have been the reason for higher yield in second year.

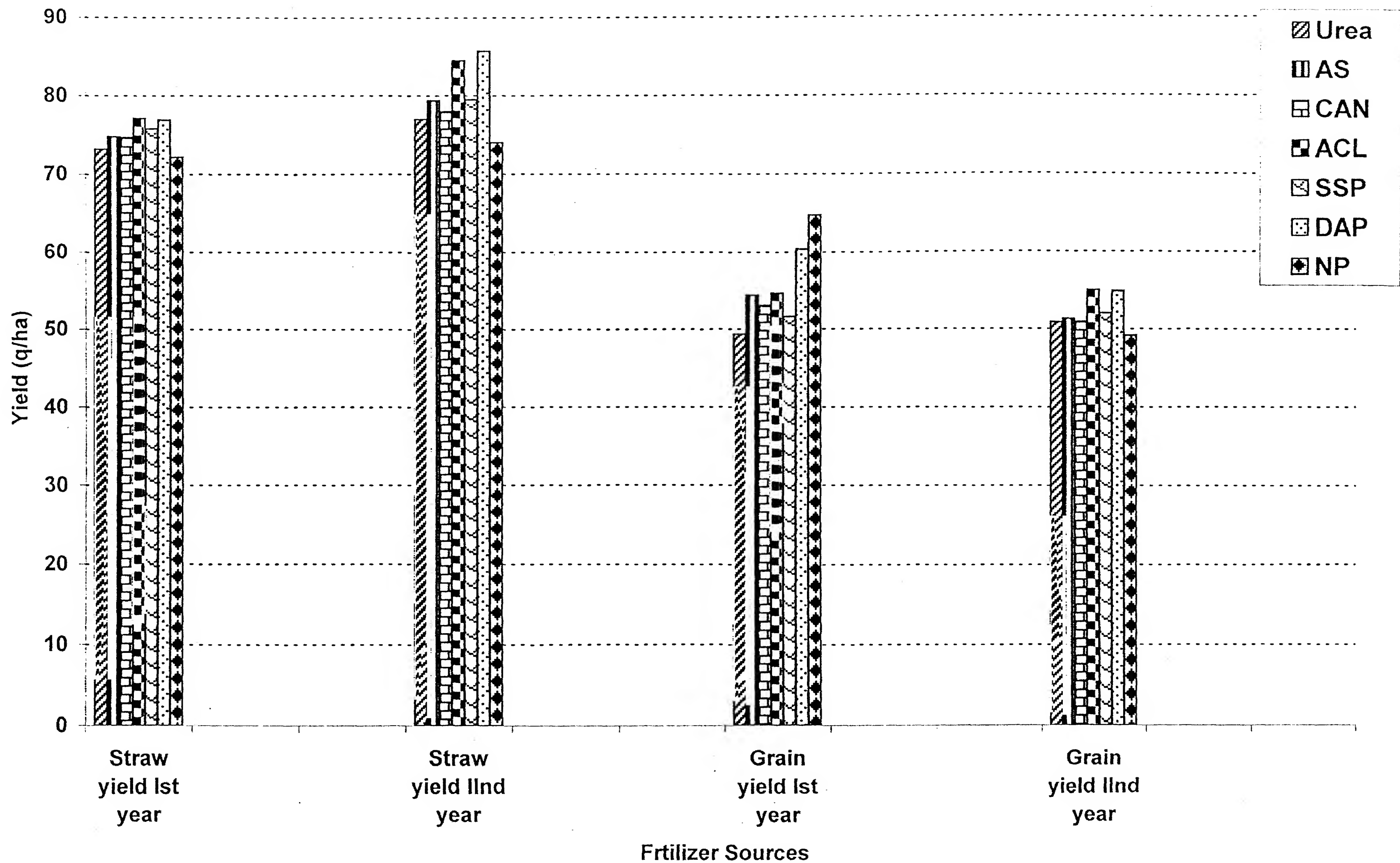
Diammonium phosphate produced maximum straw yield followed by single super phosphate. Nitrophos produced lowest straw yield among the different phosphatic sources. In second year similar results were obtained with little higher straw yield.

The interaction effect of ammonium chloride with diammonium phosphate produced maximum straw yield which was closely followed by ammonium sulphate with diammonium phosphate. In the second year same results were obtained with higher straw yield than first year. Improved utilization of nitrogen supplied through ammoniacal form may be the reason for better performance of ammonium form of nitrogenous fertilizers.

Table 11: Grain and straw yield of Rice as affected by different sources of nitrogenous and phosphatic fertilizers

	Straw Yield (q/ha)								Grain Yield (q/ha)							
Source	**First Year**				**Second Year**				**First Year**				**Second Year**			
Phosphorus / Nitrogen	**SSP**	**DAP**	**NP**	**AV**	**SSP**	**DAP**	**NP**	**AV**	**SSP**	**DAP**	**NP**	**AV**	**SSP**	**DAP**	**NP**	**AV**
Urea	74.20	78.20	67.20	**73.20**	78.40	84.60	70.80	**77.00**	49.05	57.15	42.00	**49.40**	52.50	55.40	45.00	**50.90**
AS	74.00	79.00	79.30	**74.80**	74.00	91.00	72.00	**79.40**	56.50	59.00	47.85	**54.45**	49.20	55.40	49.50	**51.37**
CAN	75.60	70.40	78.40	**74.70**	78.20	76.40	79.40	**78.00**	50.85	58.20	50.25	**53.10**	51.00	49.90	52.50	**51.00**
Acl	79.40	80.00	72.00	**77.10**	87.60	92.00	74.00	**84.50**	50.25	67.20	46.65	**54.70**	55.70	59.50	50.10	**55.10**
AV	**75.80**	**76.90**	**72.20**		**79.50**	**85.70**	**74.00**		**51.66**	**60.40**	**46.70**		**52.10**	**54.95**	**49.20**	
CD For	**N**	**P**	**NxP**		**N**	**P**	**NxP**		**N**	**P**	**NxP**		**N**	**P**	**NxP**	
At 5%	2.23	1.93	3.87		2.61	2.26	4.52		2.45	2.12	4.25		1.33	1.15	2.29	
At 1%	3.03	2.63	5.25		3.55	3.07	6.15		3.33	2.89	5.77		1.80	1.56	3.12	

Fig. 8: Grain and Straw yield of Rice as affected by different treatments



GRAIN YIELD:

Grain yield of rice influenced by different sources of nitrogen, phosphorus an their interactions are given in table 11 and depicted through figure 8.

The grain yield of rice significantly different under different sources of nitrogen, phosphorus and their interactions. Amongst the nitrogenous sources ammonium chloride produced maximum grain yield followed by ammonium sulphate (Malik and Das, 1995). Whereas, minimum grain yield was obtained by the application of urea as nitrogen sources. Grain yield produced in second year was higher than the previous year with the similar result as in first year.

Amongst different sources of phosphorus, diammonium phosphate produced maximum grain yield (60.40 q/ha) followed by single super phosphate (51.66 q/h). Grain yield of rice produced by nitrophos was minimum (46.70 q/ha). In second ye similar results were obtained with highest grain yield under diammonium phosph, (54.95 q/ha). Interaction of diammonium phosphate with ammonium chloride produced highest grain yield followed by diammonium phosphate with ammonium sulphate. The performance of urea with nitrophos was poorest among all interactions.

GROWTH PARAMETERS OF WHEAT:

PLANT HEIGHT:

Data pertaining to plant height of wheat at successive growth stages including at maturity as affected by different treatments are given in table 12 & 13 a graphically depicted through figoure 9 and 10. From the data it is clear that plant height of wheat gradually increased up to 90 DAS under all treatments, but maturity plant height reduced slightly.

Different sources of nitrogen produced non-significant difference in plant height with numerical superiority of calcium ammonium nitrate over other sources This trend in of plant height of wheat was followed at all growth stages. Whereas the

dwarfest plants of wheat were produced under the treatment receiving nitrogen through urea. There was non-significant difference in plant height of wheat under all phosphatic sources with numerical superiority of single super phosphate over rest of the sources. But the plant height of wheat was minimum under the treatment receiving phosphorus through nitrophos. The interaction effect was also non-significant for the plant height of wheat. Second year observations confirm the findings of first year.

TILLER COUNT (m^{-2}):

Data concerning number of tillers/m^2 at different growth stages of wheat as influenced by different treatments are presented in table 14 and 15 also illustrated through figure 11 and 12.

Number of tillers per meter square area was significantly affected by different sources of nitrogen at all growth stages including maturity. Highest number of tillers produced by applying nitrogen through ammonium sulphate, this was followed by ammonium chloride. (Venkateswarly *et al.,* 1970; Saxena , 1966). Whereas minimum tiller produced under the treatment receiving nitrogen through calcium ammonium nitrate. Better utilization of applied nitrogen and reduction in losses, when nitrogen was applied through ammoniacal form may be the reason for higher tiller count (Gasser and Iordan 1967), similar results in second year confirms the findings.

Among the phosphatic sources diammonium phosphate produced significantly higher number of tillers in wheat crop. This was closely followed by single super phosphate, whereas minimum tiller was produced under nitrophose (Misra and Singh 1968).

The interaction of nitrogen and phosphorus showed its significant effect on tiller count. The interaction of ammonium sulphate with diammonium phosphate

Table 12: Plant height of Wheat as affected by different sources of nitrogenous and phosphatic fertilizer during first year

Source	30 DAT				60 DAT				90 DAT				At Harvest			
Phosphorus / Nitrogen	SSP	DAP	NP	AV	SSP	DAP	NP	AV	SSP	DAP	NP	AV	SSP	DAP	NP	AV
Urea	25.50	23.90	21.80	**23.70**	67.10	66.70	60.10	**64.40**	93.90	92.50	88.20	**91.50**	90.80	92.40	87.70	**90.30**
AS	24.10	23.20	22.70	**23.30**	67.40	64.90	63.50	**65.30**	93.40	92.10	91.70	**92.40**	91.90	90.10	92.60	**91.30**
CAN	25.80	23.70	26.10	**25.20**	67.70	64.10	67.90	**66.60**	94.20	91.60	96.60	**94.10**	92.80	93.40	95.40	**93.90**
Acl	26.10	22.00	23.91	**24.00**	67.30	62.80	64.90	**65.00**	95.90	90.10	92.50	**92.80**	91.30	91.20	93.70	**92.10**
AV	**25.40**	**23.20**	**23.60**		**67.40**	**64.60**	**64.10**		**94.40**	**91.60**	**92.30**		**91.50**	**91.80**	**93.40**	
CD For	N	P	NxP		N	P	NxP		N	P	NxP		N	P	NxP	
At 5%	NS	NS	NS		NS	NS	NS		NS	NS	NS		NS	NS	NS	
At 1%	NS	NS	NS		NS	NS	NS		NS	NS	NS		NS	NS	NS	

Fig. 9: Plant height of Wheat as affected different treatments during first year

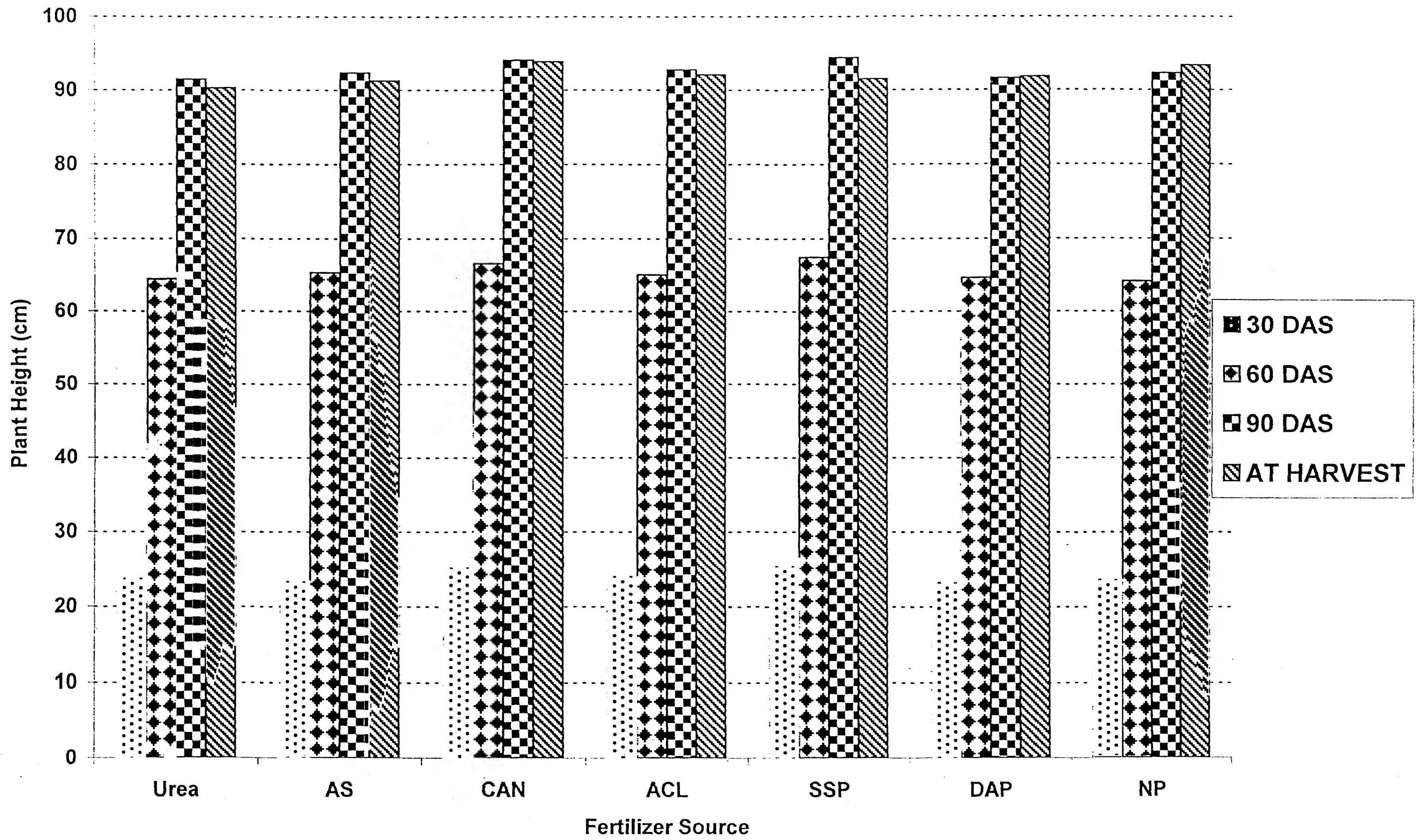
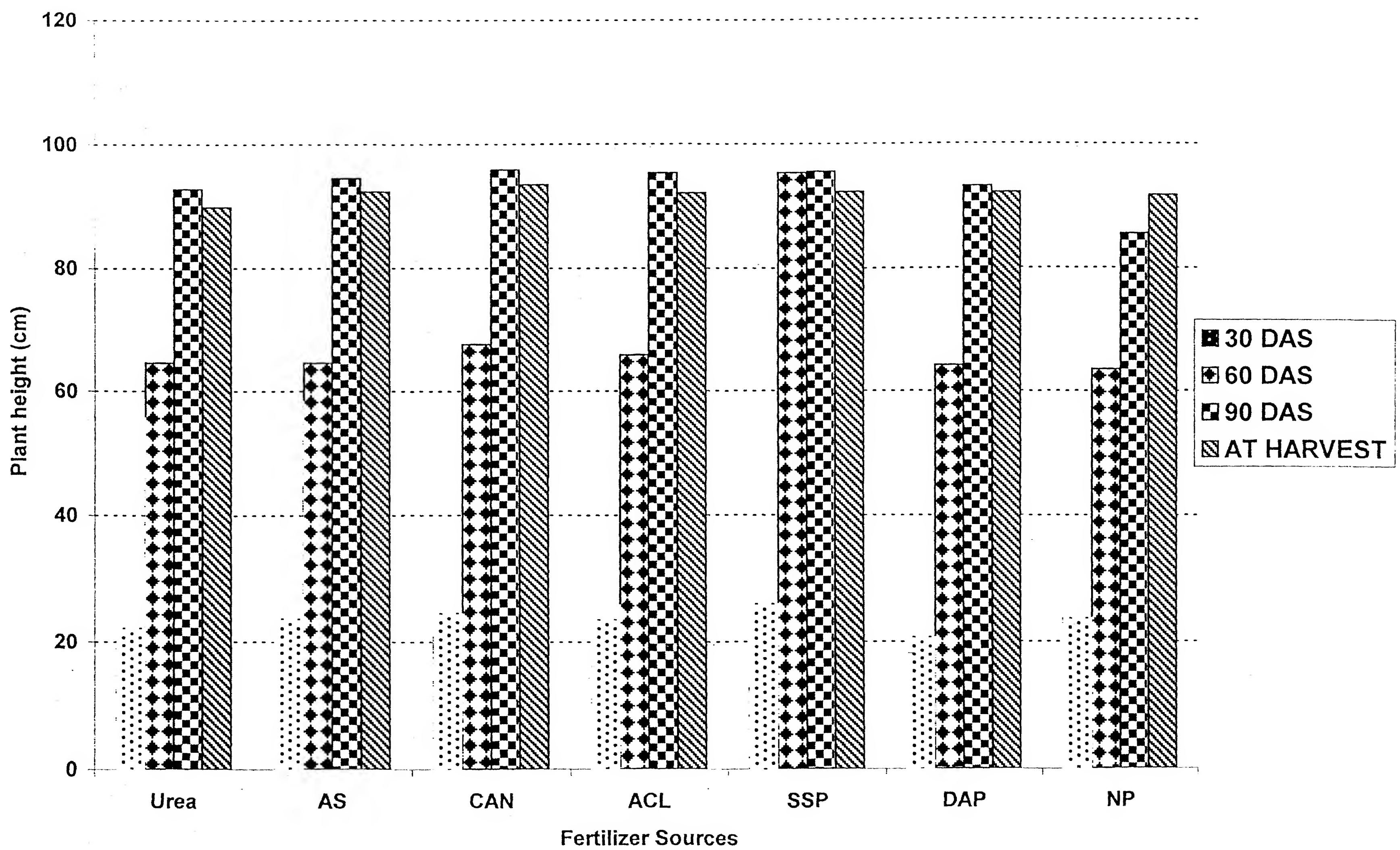


Table 13: Plant height of Wheat as affected by different sources of nitrogenous and phosphatic fertilizer during second year

Source	30 DAS				60 DAS				90 DAS				At Harvest			
Phosphorus / Nitrogen	SSP	DAP	NP	AV	SSP	DAP	NP	AV	SSP	DAP	NP	AV	SSP	DAP	NP	AV
Urea	24.10	20.70	21.70	**22.20**	69.70	64.00	60.10	**64.60**	93.20	95.60	89.70	**92.80**	91.21	91.80	86.90	**89.90**
AS	25.60	20.50	24.70	**23.60**	69.70	63.80	60.40	**64.60**	95.50	93.40	94.70	**94.50**	92.30	91.70	93.30	**92.40**
CAN	26.70	21.30	25.40	**24.50**	69.70	65.40	67.80	**67.60**	98.10	90.00	99.70	**95.90**	93.10	92.60	94.90	**93.50**
Acl	27.50	20.40	22.50	**23.50**	68.70	63.40	65.70	**65.90**	95.70	93.70	96.70	**95.40**	92.60	92.30	91.60	**92.20**
AV	**25.90**	20.70	**23.60**		**95.40**	**64.20**	**63.50**		**95.60**	**93.20**	**85.60**		**92.30**	**92.10**	**91.70**	
CD For	N	P	NxP		N	P	NxP		N	P	NxP		N	P	NxP	
At 5%	NS	NS	NS		NS	NS	NS		NS	NS	NS		NS	NS	NS	
At 1%	NS	NS	NS		NS	NS	NS		NS	NS	NS		NS	NS	NS	

Fig. 10: Plant heigh of Wheat as affected by different treatments during second year



produced significantly higher tiller count than others. This may be because of higher availability of nitrogen to wheat plant (Borkowski and Kozera ,1956)

YIELD ATTRIBUTING CHARACTERS:

EFFECTIVE TILLERS (m^{-2}):

Data related to effective tillers per meter square at different growth stages of wheat as influenced by different nitrogen and phosphorus sources of fertilizer are given in table 16 and 17 and also depicted through figure 11 and 12.

Number of effective tillers produced by ammonium sulphate was highly significant as compared to other nitrogen sources (Volk and Tidmore 1954) this was followed by the treatment receiving nitrogen through urea. Better and efficient physiological process under these treatments may be the probable reason for higher number of effective tillers. The performance of calcium ammonium nitrate was poorest for effective tillers, which lead to minimum number of effective tillers under the treatment (Sengupta and Das , 1962).

Among the phosphatic sources, diammonium phosphate produced significantly higher number of effective tillers as compared to other sources (Ramasubramomi *et al.,* 1962; Venkatarao,1964). This was followed by the treatment receiving phosphorus through nitrophos. But the performance of single super phosphate was poorest on effective tillers, which lead to the production of minimum number of effective tillers.

The interaction effect was also significant, combination of ammonium sulphate with single super phosphate produced highest number of effective tillers per meter area.

Table 14: Tiller count of Wheat as affected by different sources of nitrogenous and phosphatic fertilizer during first year

Source	30 DAS				60 DAS				90 DAS				At Harvest			
Phosphorus / Nitrogen	SSP	DAP	NP	AV	SSP	DAP	NP	AV	SSP	DAP	NP	AV	SSP	DAP	NP	AV
Urea	298.0	343.2	325.2	**325.5**	372.0	379.2	366.0	**372.4**	292.0	321.8	309.8	**307.9**	274.8	324.3	315.0	**304.7**
AS	392.6	382.0	392.6	**363.1**	437.2	402.0	346.0	**395.1**	340.0	336.0	302.0	**326.0**	335.3	331.5	298.4	**321.7**
CAN	314.6	335.2	314.6	**323.9**	342.0	330.0	350.0	**340.7**	320.0	300.0	286.0	**310.0**	315.6	296.7	282.9	**298.4**
Acl	324.6	397.2	324.6	**341.5**	358.0	420.6	340.0	**372.9**	278.8	286.0	320.4	**309.1**	318.5	316.2	307.0	**313.9**
AV	**322.5**	**364.4**	**316.1**		**377.3**	**382.9**	**350.5**		**307.7**	**321.5**	**304.5**		**311.1**	**317.2**	**300.8**	
CD For	N	P	NxP		N	P	NxP		N	P	NxP		N	P	NxP	
At 5%	2.54	2.19	4.39		21.29	18.4	36.8		5.68	4.92	9.83		21.12	18.29	35.58	
At 1%	3.45	2.99	5.98		28.8	25.0	50.0		7.72	6.68	13.36		28.71	21.86	49.72	

Fig. 11: Tiller count of Wheat as affected by different treatments during first year

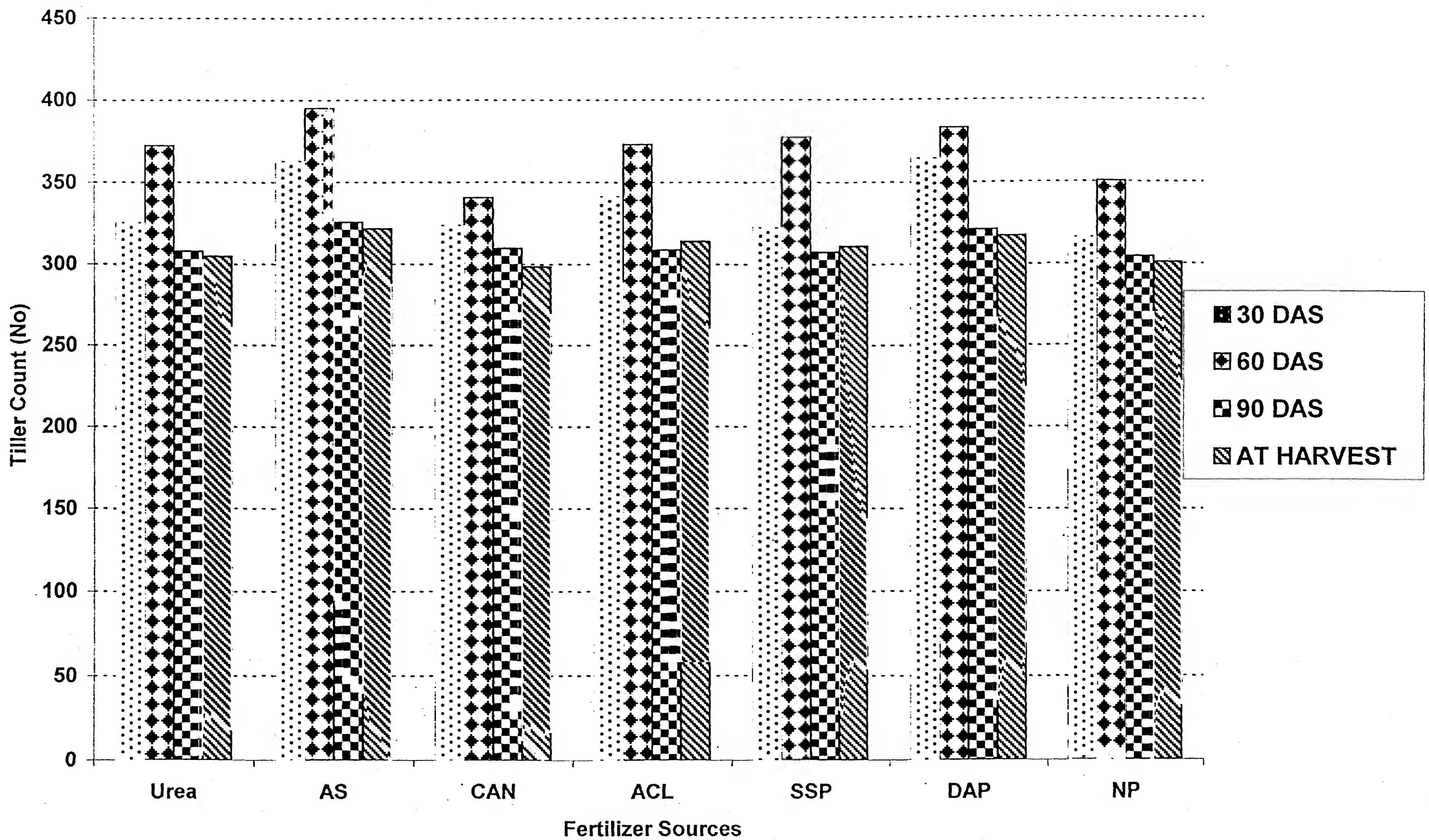
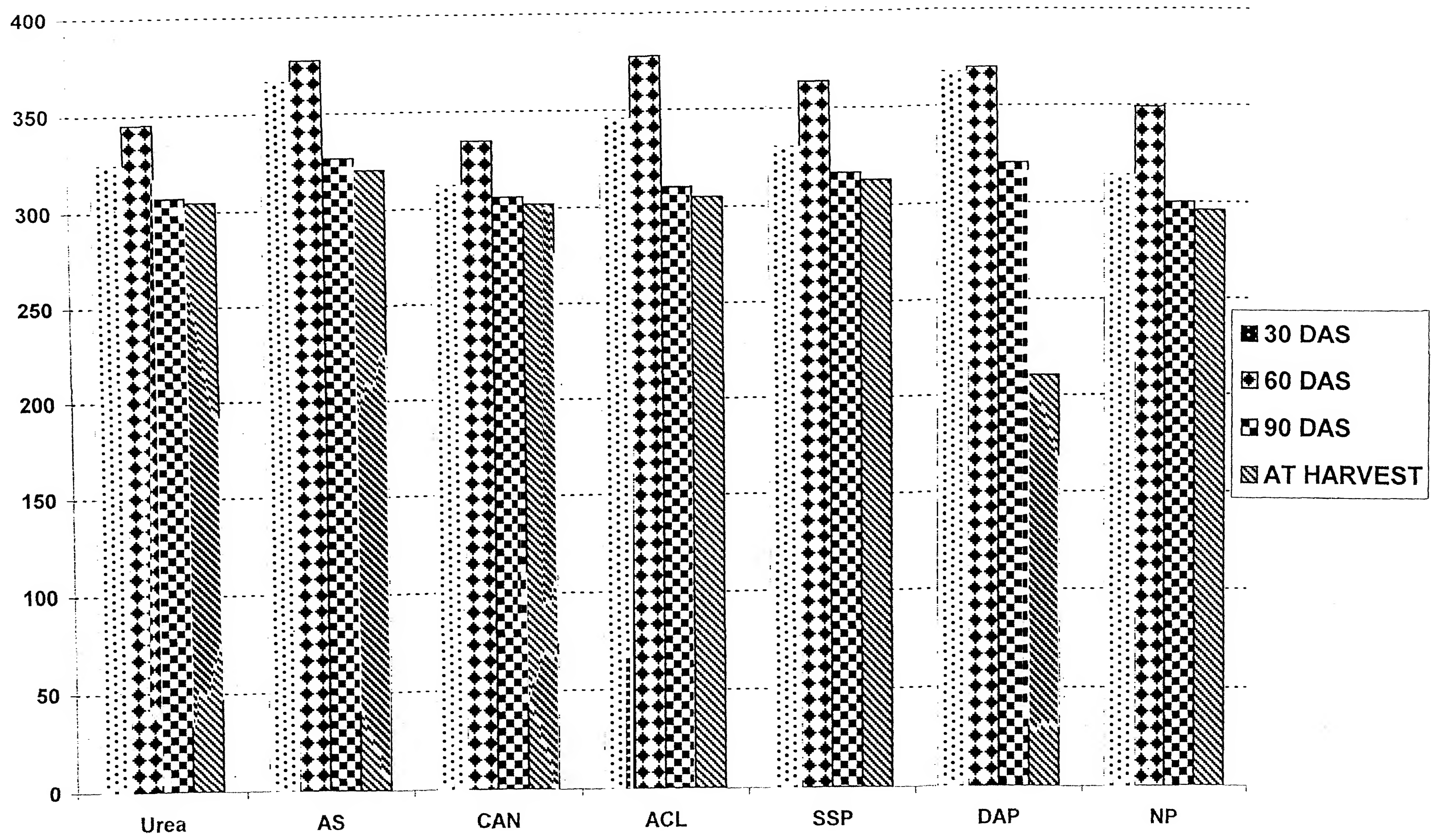


Table 15: Tiller count of Wheat as affected by different sources of nitrogenous and phosphatic fertilizer during second year

Source	30 DAS				60 DAS				90 DAS				At Harvest			
Phosphorus / Nitrogen	SSP	DAP	NP	AV	SSP	DAP	NP	AV	SSP	DAP	NP	AV	SSP	DAP	NP	AV
Urea	291.4	360.6	322.0	**324.7**	359.5	334.8	341.4	**345.2**	484.6	320.6	316.2	**307.1**	293.9	295.7	295.7	**304.8**
AS	374.8	406.0	320.0	**366.9**	387.4	410.8	334.8	**377.7**	353.4	326.6	300.8	**326.9**	347.7	21.7	296.4	**320.5**
CAN	314.8	301.4	320.2	**312.1**	319.4	342.8	351.2	**334.8**	329.4	306.8	281.0	**305.7**	327.5	201.9	275.7	**301.9**
Acl	340.8	403.0	294.0	**345.9**	389.4	373.4	369.0	**377.8**	299.6	329.0	301.8	**310.1**	282.5	211.9	314.5	**305.0**
AV	**330.5**	**367.7**	**314.1**		**363.9**	**369.9**	**349.1**		**316.7**	**320.7**	**299.9**		**312.9**	**210.4**	**295.6**	
CD For	N	P	NxP		N	P	NxP		N	P	NxP		N	P	NxP	
At 5%	6.19	5.73	10.74		8.39	7.29	14.54		4.85	4.19	8.39		7.07	6.12	12.25	
At 1%	8.42	7.29	14.59		11.41	9.88	19.77		6.59	5.71	11.41		9.61	8.32	16.64	

Fig. 12: Tiller count of Wheat as affected by different treatments during second year



GRAIN PER SPIKE :

Data concerning number of grains per spike as influenced by different treatment is presented in table 16 and 17 and also depicted through figure 13 and 14.

The observations in table clearly indicate that, source of nitrogen and phosphorus had significant effect on grains per spike. But the interaction effect of these two do not have its marked effect on the same character.

Ammonium sulphate produced highest grain per spike, which was closely followed by ammonium chloride. This may be because of efficient storage of food in grain and better source sink relationship under this treatment. Minimum grain per spike was produced by the treatment receiving nitrogen through urea. Whereas in second year minimum number of grains per spike was produced under calcium ammonium nitrate.

Among the phosphatic sources, diammonium phosphate was best for this character, (Iruthayaraj and Rajarathnam 1965) which was followed by single super phosphate. But the number of grains per spike was minimum under the treatment receiving phosphorus through nitrophos (Roy chaudhari,1965). The interaction of nitrogen with phosphorus did not have its marked effect on grain per spike.

TEST WEIGHT :

The data related to test weight is presented in table 16 and 17 and also depicted in figure 13 and 14. Even this is a varietal character, it differs significantly under different nitrogen and phosphatic sources. Whereas the interaction did not have its effect on test weight.

Maximum test weight was observed under the treatment receiving nitrogen through ammonium sulphate followed by ammonium chloride. But the treatment receiving nitrogen through urea produced minimum test weight (Chaudhari and Balra, 1992).

Table 16: Yield attributing characters of Wheat as influenced by different sources of nitrogenous and phosphatic fertilizer during first year

Source	Effective tillers (m^2)				Grain per panicle				Test weight (g)			
Phosphorus / Nitrogen	SSP	DAP	NP	AV	SSP	DAP	NP	AV	SSP	DAP	NP	AV
Urea	272.5	319.5	308.3	**300.1**	56.0	58.1	57.8	**57.3**	43.1	41.2	47.6	**58.9**
AS	332.1	328.8	293.4	**318.1**	59.6	64.7	56.8	**60.4**	55.1	53.6	47.3	**60.8**
CAN	310.1	291.1	274.9	**292.0**	61.1	56.9	56.3	**58.1**	50.6	47.3	44.3	**59.2**
Acl	314.6	311.3	305.3	**310.4**	59.0	62.0	59.0	**60.0**	47.3	57.2	44.3	**59.6**
AV	**307.3**	**312.7**	**295.5**		**58.9**	**60.4**	**57.5**		**49.0**	**52.3**	**45.9**	
CD For	N	P	NxP		N	P	NxP		N	P	NxP	
At 5%	18.12	15.29	30.20		2.05	1.77	NS		0.38	0.33		
At 1%	24.72	21.86	42.71		2.78	2.41	NS		0.51	0.45		

Fig. 13: Yield attributes of Wheat as affected by different treatments during first year

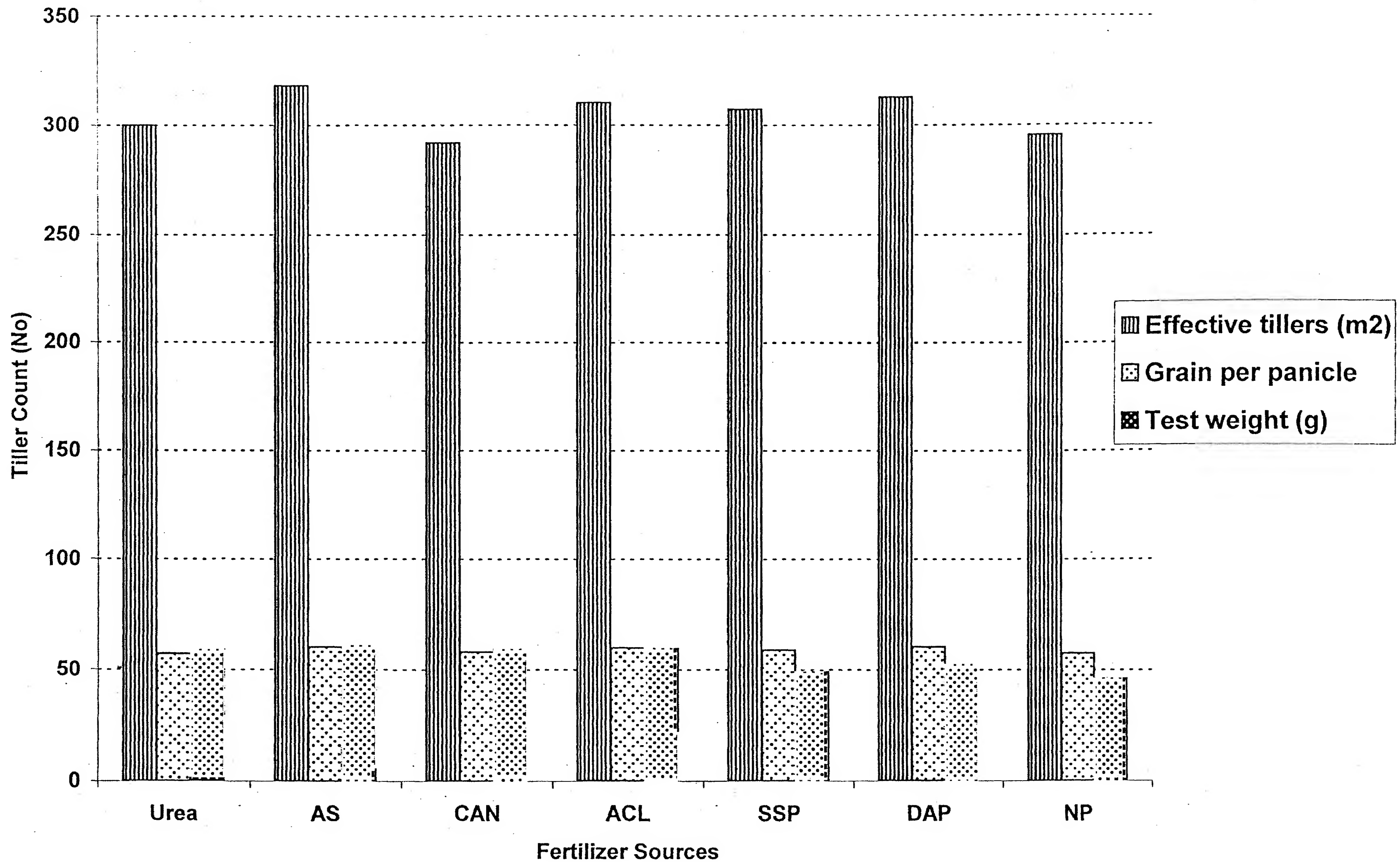
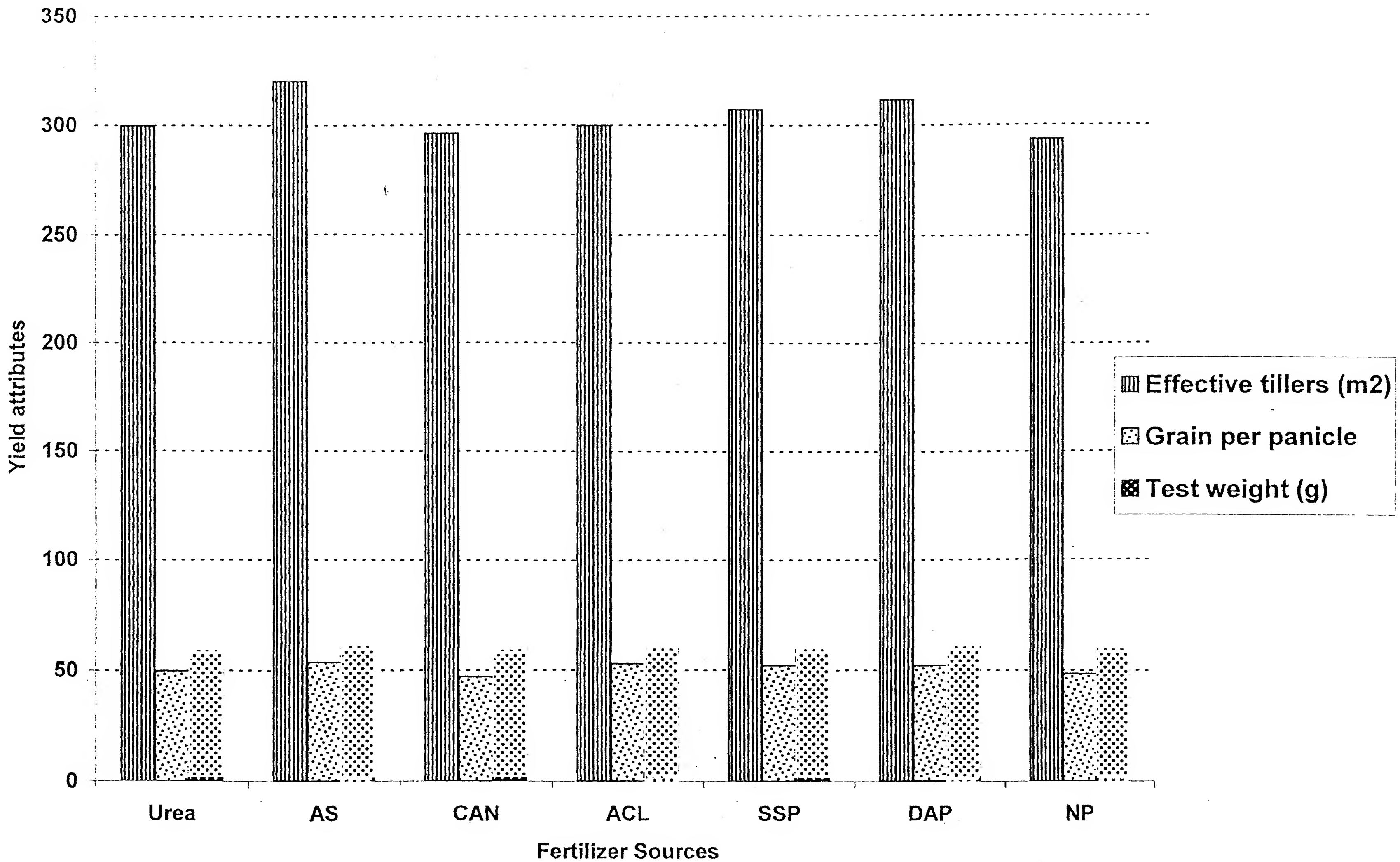


Table 17: Yield attributing characters of Wheat as influenced by different sources of nitrogenous and phosphatic fertilizer during second year

Source	Effective tillers (m^2)				Grain per panicle				Test weight (g)			
Phosphorus / Nitrogen	SSP	DAP	NP	AV	SSP	DAP	NP	AV	SSP	DAP	NP	AV
Urea	290.8	319.9	289.2	**299.9**	50.3	51.2	41.7	**49.8**	58.4	59.0	59.3	**58.9**
AS	340.8	312.3	307.9	**320.3**	56.0	53.2	50.9	**53.4**	60.8	61.7	59.9	**60.8**
CAN	321.9	294.1	272.2	**296.3**	49.1	48.5	44.3	**47.3**	59.3	59.6	58.7	**59.2**
Acl	275.1	320.1	304.6	**299.9**	53.0	56.0	50.0	**53.0**	58.7	60.8	59.3	**59.6**
AV	**307.2**	**311.6**	**293.5**		**52.1**	**52.2**	**48.3**		**59.3**	**60.3**	**59.3**	
CD For	**N**	**P**	**NP**		**N**	**P**	**NxP**		**N**	**P**	**NP**	
At 5%	6.89	5.96	11.69		2.98	2.58	NS		0.69	0.86	NS	
At 1%	9.42	8.12	15.96		4.05	3.51	NS		0.95	0.82	NS	

Fig. 14: Yield attributes of Wheat as affected by different treatment during second year



Among the phosphatic sources, diammonium phosphate was the best for this character. But minimum test weight was observed under nitrophos treatment observations recorded in second year confirms the findings of first year.

GRAIN YIELD:

Data related to grain yield as affected by different treatments is presented through table 18 and depicted in figure 15.

The grain yield was significantly higher under the treatment receiving nitrogen through ammonium sulphate, this was followed by ammonium chloride. But the performance of urea and calcium ammonium nitrate for grain yield was at par with numerical superiority of urea over calcium ammonium nitrate. Better nitrogen use efficiency may be the reason for higher grain yield under treatment receiving nitrogen through ammoniacal source (Maldeniga and Theababu,1977).

Among the phosphatic sources, maximum grain yield was obtained under the treatment receiving phosphorus through single super phosphate. This was closely followed by diammonium phosphate but the performance of nitrophos was poorest grain yield. Sulphur is associated with single super phosphate, which is benefited for higher grain yield under this treatment.

The interaction of two sources of fertilizer showed its significant effect on grain yield. Application of nitrogen through ammonium sulphate along with application of phosphorus through diammonium phosphate produced highest grain yield.

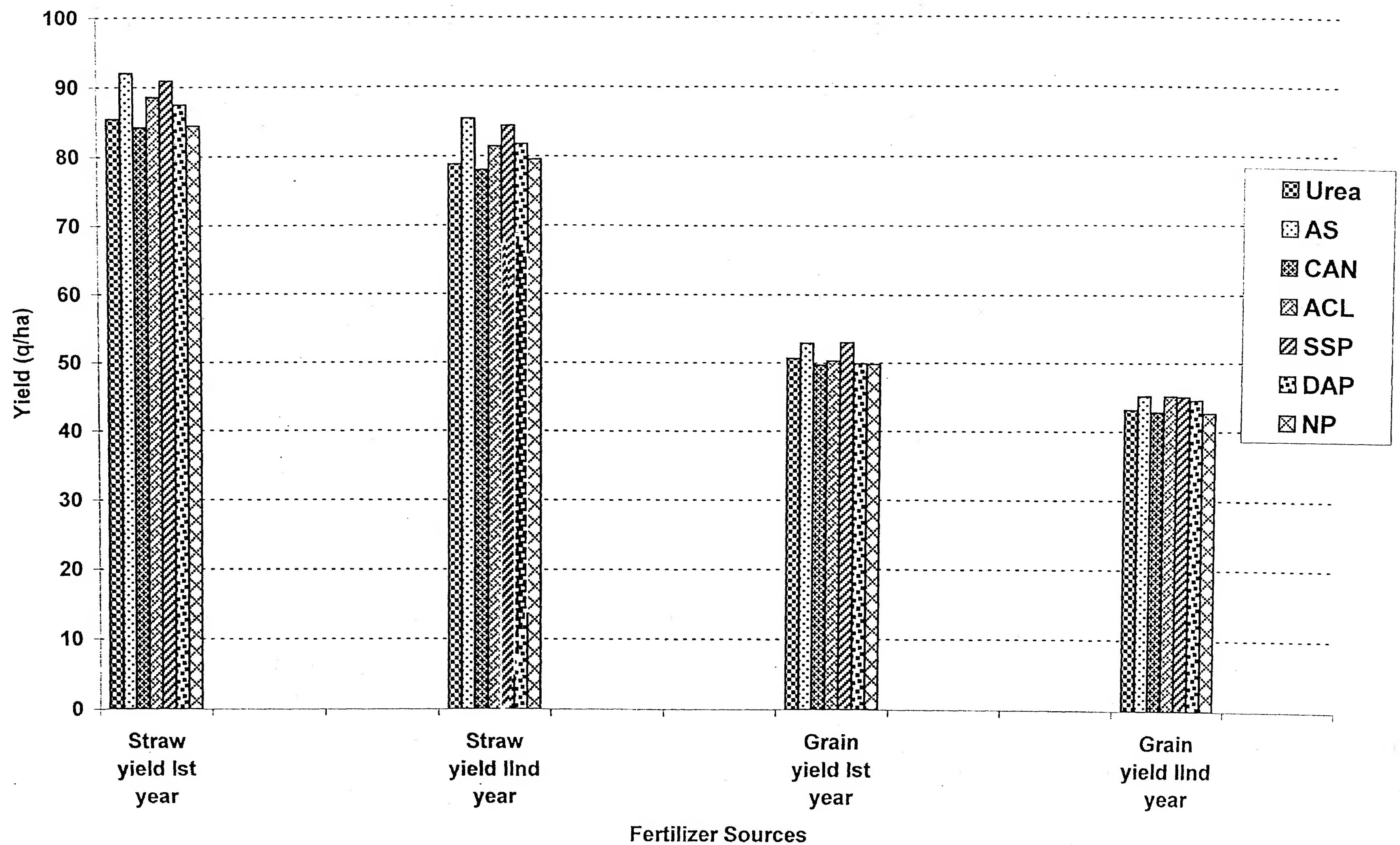
STRAW YIELD:

Data pertaining to straw yield as influenced by different treatments were presented in table 18 and also depicted in figure 15. The data show that the straw

Table 18: Grain and straw yield of Wheat as affected by different sources of nitrogenous and phosphatic fertilizers

Source	Straw Yield (q/ha)								Grain Yield (q/ha)							
	First Year				Second Year				First Year				Second Year			
Phosphorus / Nitrogen	SSP	DAP	NP	AV	SSP	DAP	NP	AV	SSP	DAP	NP	AV	SSP	DAP	NP	AV
Urea	85.90	91.10	91.20	**85.40**	81.70	77.90	76.70	**78.80**	53.90	50.30	48.10	**50.70**	45.70	41.80	42.40	**43.20**
AS	96.70	92.80	86.70	**92.10**	84.90	92.70	78.60	**85.40**	53.10	56.40	49.10	**52.90**	46.10	47.70	41.70	**45.20**
CAN	85.90	82.10	84.70	**84.20**	84.20	72.70	77.10	**78.00**	52.70	44.10	52.30	**49.70**	46.90	41.30	40.60	**42.90**
Acl	94.90	83.90	83.90	**88.60**	86.60	83.70	73.80	**81.40**	52.40	48.90	49.50	**50.30**	41.70	47.70	46.10	**45.20**
AV	**90.90**	**87.50**	**84.40**		**84.35**	**81.75**	**79.50**		**53.00**	**49.90**	**49.80**		**45.10**	**44.60**	**42.70**	
CD For	N	P	NxP		N	P	NxP		N	P	NxP		N	P	NxP	
At 5%	1.22	1.06	2.12		1.85	1.60	3.20		1.23	1.06	2.12		1.74	1.51	3.01	
At 1%	1.66	1.44	2.87		1.68	2.18	4.36		1.67	1.45	2.89		2.36	2.05	4.09	

Fig. 15: Grain and Straw Yield of Wheat as affected by different treatment



yield was significantly affected by sources of nitrogen, phosphorus and their interactions.

Similarly, straw yield under ammonium sulphate treatment was significantly 1igher than other treatments. This was followed by the treatment receiving nitrogen through ammonium chloride. But the straw yield was minimum under calcium ammonium nitrate. Among the phosphatic sources, single super phosphate produced highest straw yield followed by diammonium phosphate. But the performance of nitrophos was not good as it produced minimum straw yield.

Interaction of ammonium sulphate with single super phosphate was the best combination for higher straw yield.

PROTEIN CONTENT :.

Data pertaining to percent protein content in grain as affected by different sources of nitrogen and phosphorus are given in table 19 and also depicted in figure 16

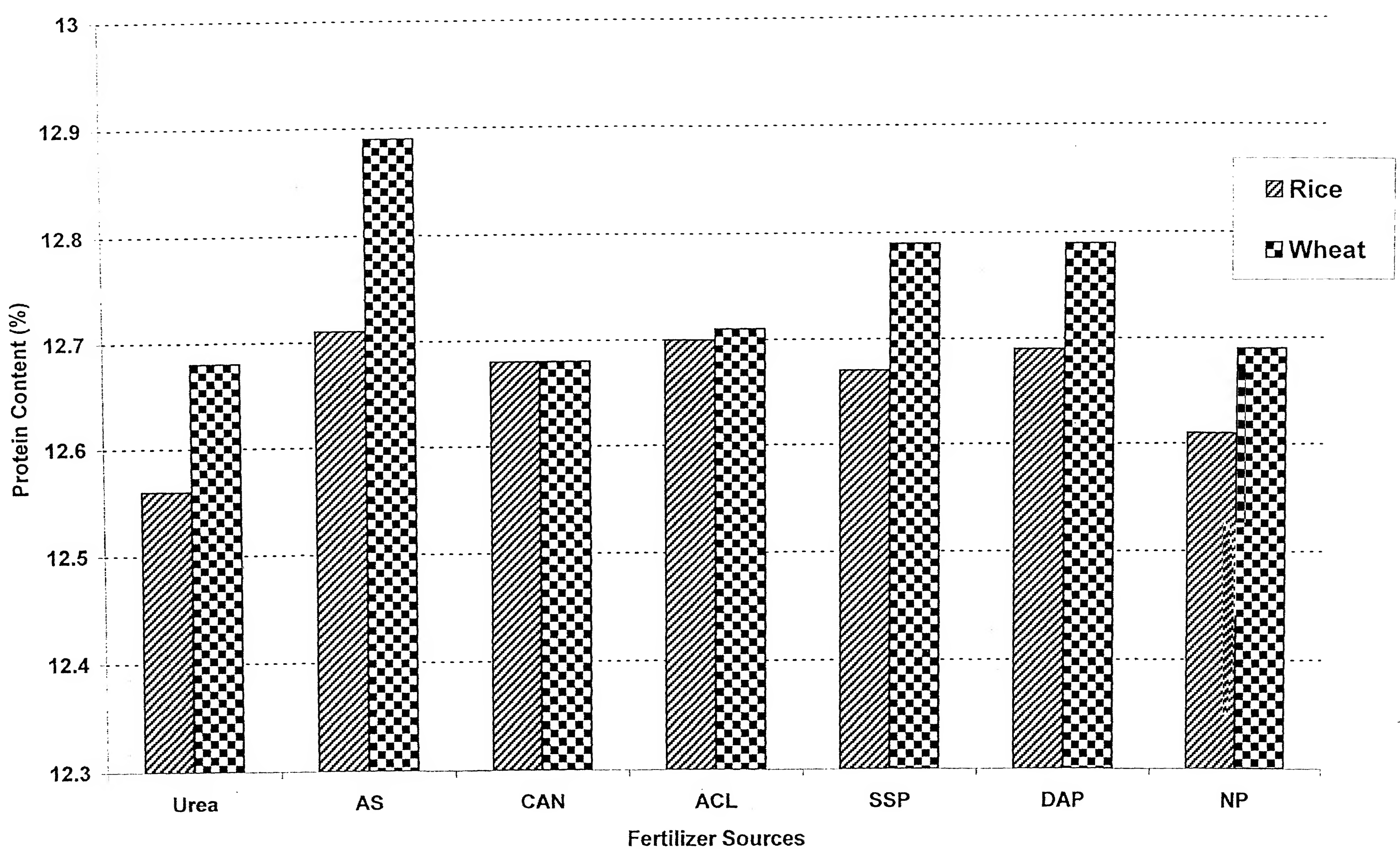
Percent protein content of rice and wheat grain remained unaffected as the differences were not significant. Among the nitrogenous fertilizers, ammonium sulphate produced highest protein content in grains of rice and wheat. It was closely 'allowed by ammonium chloride. Better fertilizer use efficiency under ammoniacal source of nitrogen may be the probable reason for the higher protein content. Protein content in rice and wheat grain was minimum under the treatment receiving nitrogen through urea.

Among the phosphatic sources diammonium phosphate produced grains with highest protein content in rice and wheat, but this difference was not significant. Presence of ammoniacal nitrogen in diammonium phosphate may be the probable reason for higher protein content in grain. The performance of nitrophos was not good as it produced minimum protein content in grains.

Table 19: Protein content (%) in grain of Rice and Wheat as influenced by different source of nitrogenous and phosphatic fertilizers

Source	Rice				Wheat			
Phosphorus / Nitrogen	SSP	DAP	NP	AV	SSP	DAP	NP	AV
Urea	12.57	12.59	12.52	**12.56**	12.79	12.72	12.64	**12.68**
AS	12.74	12.76	12.64	**12.71**	12.90	12.93	12.84	**12.89**
CAN	12.68	12.71	12.65	**12.68**	12.73	12.75	12.71	**12.68**
Acl	12.71	12.73	12.66	**12.70**	12.72	12.76	12.56	**12.71**
AV	**12.67**	**12.69**	**12.61**		**12.79**	**12.79**	**12.69**	
CD For	**N**	**P**	**NxP**		**N**	**P**	**NxP**	
At 5%	NS	NS	NS		NS	NS	NS	
At 1%	NS	NS	NS		NS	NS	NS	

Fig. 16: Protien content of grain as affected by different treatments



The interaction of nitrogen and phosphatic fertilizers was also not significant. But numerical superiority was observed under the treatment combination receiving nitrogen through ammonium sulphate and phosphorus through diammonium phosphate in both rice and wheat.

ECONOMICS :

The procedures for calculating the economics under different treatments are given in appendix. The final values of economic analysis for rice and wheat under different treatments are gives in table 22. The cost of cultivation for rice varied from Rs. 11651.20/ha under N_1 P_1 to Rs. 15785.70/ha under N_2 P_3. Similarly cost of cultivation for wheat ranged from Rs. 9961.20/ha under N_1 P_2 to Rs. 14097.70/ha under the treatment N_2 P_3. Thus total cost of cultivation for entire rice-wheat system ranged from Rs. 21612.40/ha under N_1 P_2 to Rs. 29883.40/ha under N_2 P_3. The gross monetary return (GMR) and net monetary return (NMR) also varied for both crops under different treatments. The mean values of economic analysis of different treatments are given in table 23.

COST OF CULTIVATION :

The value ranged from Rs. 12063.07/ha to Rs. 15376.17/ha under different treatments. Among the nitrogenous sources for rice, cost of cultivation was lowest under the treatment receiving urea whereas it was highest under ammonium sulphate treatment. But for phosphatic source diammonium phosphate required minimum cost of cultivation, whereas it was highest for nitrophos treatment. Similarly in case of wheat highest cost of cultivation was recorded under ammonium sulphate and nitrophos treatment, whereas it was lowest under the treatment receiving urea and diammonium phosphate.

Among the interactions highest cost of cultivation of rice was under the treatment receiving nitrogen through ammonium sulphate and phosphorus through

Table 20 : Economics of Rice and Wheat (Rs/ha/annum)under different sources of nitrogenous and phosphatic fertilizer

Treat.	Cost of Cultivation			Gross Return			Net Return			Benefit :cost Ratio		
	Rice	Wheat	Total	Rice	Wheat	Total	Rice	Wheat	Total	Rice	Wheat	Total
N_1P_1	11651.2	9961.20	21612.4	34461.2	32315.5	66776.7	22810.0	22354.3	45164.3	2.96	3.24	3.09
N_1P_2	11957.6	10267.6	22225.2	31355.0	34568.0	65923.0	19397.4	24300.4	43697.8	2.62	3.37	2.97
N_1P_3	12580.4	10890.4	23470.8	26940.0	31800.0	58740.0	14359.6	20909.6	35269.2	2.14	2.92	2.50
N_2P_1	14978.6	13288.6	28267.2	34938.0	3688.00	71326.0	19959.4	23099.4	43058.2	2.33	2.74	2.52
N_2P_2	15364.2	13674.2	29038.4	32239.0	34796.0	67035.0	16874.8	21121.8	37996.6	2.09	2.55	2.31
N_2P_3	15785.7	14097.7	29883.4	30069.2	31826.5	61896.2	14284.0	17728.8	32012.8	1.90	2.26	2.07
N_3P_1	14704.6	13014.6	27719.2	32857.0	29917.0	62774.0	18152.4	16902.4	35054.8	2.23	2.29	2.26
N_3P_2	15078.5	13388.5	28467.0	31347.2	34630.0	65977.2	16268.7	21241.5	37510.2	2.08	2.59	2.32
N_3P_3	15530.2	13840.2	29370.4	31690.2	32379.5	64069.7	16160.0	18539.3	34699.3	2.04	2.34	2.18
N_4P_1	12998.5	11308.5	24307.0	38534.0	33653.0	72187.0	20654.5	22344.5	42999.0	2.96	2.98	2.97
N_4P_2	13318.7	11628.7	24947.4	32784.2	32238.0	65022.2	19465.5	20609.3	40074.8	2.46	2.77	2.61
N_4P_3	13905.5	12215.5	26121.0	29775.2	33100.5	62875.7	15849.7	20885.0	36734.7	2.14	2.71	2.41

nitrophos. But it was lowest under the combination of urea with diammonium phosphate.

The cost of cultivation for wheat was highest under the combination of ammonium sulphate with nitrophos, whereas it was lowest under the treatment combination of urea with diammonium phosphate.

GROSS MONETARY RETURN :

Rice crop produced highest gross monetary return under the treatment receiving nitrogen through ammonium chloride followed by ammonium sulphate, but it was minimum under urea treatment. Among the phosphatic sources rice produced highest gross monetary return under the treatment receiving diammonium phosphate whereas it was lowest under nitrophos treatment.

In case of wheat gross monetary return was highest under the treatment receiving nitrogen through ammonium sulphate but among the phosphatic sources diammonium phosphate produced highest gross monetary return, which was followed by single super phosphate.

The different combinations of nitrogen and phosphorus produced gross monetary return ranging from Rs. 26940.00/ha to Rs. 38534.00/ha. Rice crop produced maximum gross return under the treatment receiving nitrogen through ammonium chloride and phosphorus through diammonium phosphate whereas it was minimum under the combination of urea with nitrophos. But in case of wheat combination receiving nitrogen through ammonium sulphate and phosphorus through diammonium phosphate, produced maximum gross monetary return. It was minimum under the treatment combination of calcium ammonium nitrate with diammonium phosphate.

Table 21 : Economics of Rice and Wheat (Rs/ha/annum)under different sources of nitrogenous and phosphatic fertilizer

Treatments	Cost of Cultivation			Gross Return			Net Return			Benefit :Cost Ratio		
Nitrogen	**Rice**	**Wheat**	**Total**	**Rice**	**Wheat**	**Total**	**Rice**	**Wheat**	**Total**	**Rice**	**Wheat**	**Total**
Urea	12063.0	10373.07	22436.1	30918.7	32894.5	63813.2	18855.6	22521.4	41377.0	2.56	3.17	2.85
AS	15376.1	13686.8	29063.0	32415.5	34336.8	66752.4	17039.4	20650.0	37698.4	2.11	2.51	2.30
CAN	15104.4	13414.4	28578.8	31964.8	32308.8	64273.6	16860.3	18894.4	35754.7	2.11	2.41	2.25
Acl	13407.5	11717.5	25125.1	33697.8	33330.5	67028.3	20290.2	21612.9	41903.1	2.51	2.84	2.67
Phosphorus												
DAP	13583.2	11893.2	25476.5	35197.5	33068.3	68265.9	21614.3	21175.1	42789.4	2.59	2.78	2.68
SSP	13929.7	12239.7	26169.5	31931.3	34308.0	66239.3	18001.6	22068.2	40069.8	2.29	2.80	2.53
NP	14450.4	12760.9	27211.4	29618.7	32276.6	61895.4	15168.3	19515.6	34684.0	2.05	2.53	2.27

NET MONETARY RETURN :

The net monetary return of rice crop was highest under the treatment receiving nitrogen through ammonium chloride followed by urea. Whereas among the phosphatic sources diammonium phosphate produced highest net return. This was minimum under treatment receiving nitrogen through calcium ammonium nitrate and phosphorus through nitrophos.

Wheat crop produced highest net monetary return under the treatment receiving nitrogen through urea and phosphorus through single super phosphate. But it was lowest under the treatment receiving nitrogen through calcium ammonium nitrate and phosphorus through nitrophos.

Among different interactions, combination of urea with diammonium phosphate produced highest net monotony return followed by ammonium sulphate with diammonium phosphate in case of rice crop. But in case of wheat crop it was highest under treatment combination of urea with single super phosphate followed by ammonium sulphate with diammonium phosphate. Whereas minimum net return for wheat crop was obtained by the treatment combination of ammonium chloride with single super phosphate followed by ammonium chloride with nitrophos.

BENEFIT : COST RATIO :

The data concerning benefit cost ratio shows that, it was highest for urea in case of wheat crop (*i.e.* 3.17). In case or rice crop highest benefit cost ratio was under the nitrogen source urea followed by ammonium chloride. Whereas it was minimum under the treatment receiving nitrogen through calcium ammonium nitrate. But in case of phosphate source to rice, diammonium phosphate prodused highest benefit cost ratio followed by single super phosphate. Whereas nitrophos produced minimum benefit cost ratio.

The benefit cost ratios for wheat was highest under the treatment receiving nitrogen through urea and phosphorus through single super phosphate. These treatments were followed by ammonium chloride and diammonium phosphate. But the benefit cost ratio was lowest under the treatment receiving nitrogen through calcium ammonium nitrate and phosphorus through nitrophos.

Among the combinations of nitrogen and phosphorus for rice, urea with diammonium phosphate and ammonium chloride with diammonium phosphate are equally effective and produced highest benefit cost ratio. Whereas the combination of ammonium sulphate with nitrophos produced lowest benefit cost ratio.

In case of wheat this was highest under treatment combination of ammonium sulphate with single super phosphate followed by urea with diammonium phosphate. Whereas it was minimum under the combination of ammonium sulphate with nitrophos.

CHAPTER- V

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The present experiment entitled "Response of Hybrid rice and wheat to various sources of nitrogen and phosphatic fertilizers" was undertaken with the objective to find out suitable and cost effective fertilizer source of nitrogen and phosphorus for hybrid rice and wheat. A field experiment was carried out during 1998-99 and 1999-2000 at Agronomy Crop Research Farm, College of Agriculture, A.A.I.-D.U. Allahabad. The soil of experimental field was sandy loam in texture having almost neutral pH of 7.40. The organic carbon content was low with 215.00 kg/ha of available nitrogen, 47.00 kg/ha of available phosphorus and 239.00 kg/ha of available potash. A fixed layout was adopted for both the season, during *kharif* and *rabi*. The treatment comprised four sources of nitrogenous fertilizer (*i.e.* Urea, Ammonium Sulphate, Calcium Ammonium Nitrate and Ammonium Chloride) and three sources of phosphatic fertilizers (Diammonium phosphate, Single Super Phosphate and Nitrophos), which were laid out in 4 x 3 factorial design with four replications. Rice (Cv Pro–agro-6201) nursery was sown by using treated and certified seed. Transplanting of 28 days old seedlings was done on 20th July by using two seedlings per hill. Gap filling was done on 10th day after the transplanting to maintain desired plant population. Half of nitrogen along with full phosphorus and potash was applied at the time of planking. Rest half dose of nitrogen was top dressed at tillering and panical initiation stage of rice. All other agronomic operations were followed uniformly under all treatments. Physiologically matured rice was harvested on 22nd of October. Sowing of wheat Cv Lok-1 was done after the land preparation on 15th November. Full phosphorus and potash along with half nitrogen were applied as basal at the time of last planking. Rest half dose of nitrogen was top dressed after first irrigation and at panicle initiation stage. All other agronomic

operations were followed as per the recommendation. The harvesting of crop was done on 8th March. All observations were recorded, the raw data was tabulated and subjected to statistical analysis. The results obtained are summarized as under -

GROWTH PARAMETERS :

Plant height of hybrid rice was more under ammonaical form of nitrogen sources as compared to other sources. It was maximum under the treatment receiving nitrogen through ammonium sulphate, which was at par with ammonium chloride. But tallest plants of rice were produced by nitrophos whereas dwarfest plants of rice were observed under the treatment receiving phosphorus through single super phosphate. The interaction effect of nitrogen and phosphorus did not have their marked effect on plant height of rice. Tiller count was also superior under the treatments receiving nitrogen through ammonaical form but maximum tiller was produced under the treatment receiving nitrogen through ammonium chloride, which was statistically at par with ammonium sulphate. Diammonium phosphate produced maximum tiller count where as nitrophos produced minimum tillers per meter square. The interactions did not show their effect on tiller count of rice plant.

In case of wheat maximum plant height was produced by the treatment receiving nitrogen through calcium ammonium nitrate whereas dwarfest plant was observed under the treatment receiving nitrogen through urea. Among the phosphatic sources, almost equal plant height was observed, with numerical superiority of single super phosphate over others. Plant height under nitrophos was smallest. The interaction effect was non-significant, almost similar plant height was observed under all treatments. Maximum numbers of tillers were produced under the treatment receiving nitrogen through ammonium sulphate closely followed by ammonium chloride. Minimum numbers of tillers were observed under calcium ammonium nitrate treatment. Among the phosphatic sources, diammonium phosphate produced

maximum number of tillers per meter square whereas nitrophos produced minimum number of tillers. The interaction effect was significant, highest number of tillers was observed under the treatment receiving nitrogen through ammonium sulphate and phosphorus through diammonium phosphate.

YIELD ATTRIBUTING CHARACTERS :

EFFECTIVE TILLERS (m^2):

The performance of ammonium chloride was best for effective tillers than other nitrogen sources. Whereas effective tillers were minimum under urea treatment. Among the phosphatic sources, maximum effective tillers were produced by diammonium phosphate. The performance of nitrophos was not good as it produced minimum number of effective tillers. The interaction effect was not significant. Wheat crop produced maximum number of effective tillers under the treatment receiving nitrogen through ammonium sulphate and phosphorus through diammonium phosphate. Whereas minimum number of effective tillers were observed under the treatments receiving nitrogen through calcium ammonium nitrate and phosphorus through single super phosphate. In case of effective tillers of wheat the interaction effect was also significant with best performance of ammonium sulphate with single super phosphate.

GRAIN PER SPIKE :

The numbers of grains per spike was highest under the treatment receiving nitrogen through ammonium chloride followed by ammonium sulphate, whereas this was minimum under urea treatment. Among the phosphatic sources diammonium phosphate produced maximum grain per spike, while this was minimum under nitrophos treatment. The combination of ammonium chloride with diammonium

phosphate produced maximum number of grains per spike of rice. But in case of wheat, maximum grain per spike was observe under the treatment receiving nitrogen through ammonium sulphate followed by ammonium chloride. The performance of diammonium phosphate was best for grain per spike whereas nitrophos produced minimum grain per spike. The interaction effect of the treatments were not significant.

TEST WEIGHT :

The test weight of rice remained unaffected by different sources of nitrogen, phosphorus and their interaction. But in case of wheat, ammonium sulphate and diammonium phosphate produced significantly higher test weight than other sources. Whereas the interaction effect of nitrogen and phosphatic sources was not significant.

YIELD :

Hybrid rice produced highest straw and grain yield under the treatment receiving nitrogen through ammonium chloride, followed by ammonium sulphate. The performance of diammonium phosphate was superior over other sources of phosphorus to rice, it produced highest grain and straw yield. Minimum straw yield was observed under the treatment receiving nitrogen through urea and phosphorus through nitrophos respectively. Straw yield was highest under the combination of ammonium sulphate with diammonium phosphate, whereas grain yield was highest under the combination of ammonium chloride with diammonium phosphate. Similarly as in case of rice grain and straw yield of wheat was highest under the treatment receiving nitrogen through ammonium sulphate followed by ammonium chloride. But in case of phosphatic sources, single super phosphate produced highest

grain and straw yield followed by diammonium phosphate. On the other hand minimum grain and straw yield was recorded under the treatment receiving nitrogen through calcium ammonium nitrate and phosphorus through nitrophos. The straw yield was highest under the combination of ammonium sulphate with single super phosphate whereas the grain yield was highest under the combination of ammonium sulphate with diammonium phosphate.

PROTEIN :

The protein content of rice and wheat grain remained unaffected by different source of nitrogen and phosphorus however it was slightly higher under ammonium sulphate treatment than other sources of nitrogenous fertilizer. Whereas the performance of urea was not so good for the protein content of grain.

Similarly in case of wheat highest protein content was recorded under the treatment receiving nitrogen through ammonium sulphate and it was minimum under urea treatment, which was equal to calcium ammonium nitrate treatment.

Amongst the interaction of nitrogen and phosphorus, ammonium sulphate with diammonium phosphate produced maximum protein content in both rice and wheat crop.

ECONOMICS :

The cost of cultivation of both crop was highest under ammonium sulphate treatment, it was minimum under the treatment receiving nitrogen through urea. Among the phosphatic sources of fertilizers cost of cultivation was highest under the treatment receiving phosphorus through nitrophos and it was minimum under diammonium phosphate treatment.

Gross and net monetary returns were highest under the treatment receiving nitrogen through ammonium chloride, it was minimum under urea for gross monetary return and under calcium ammonium nitrate for net return. In case of rice gross return was highest under treatment receiving nitrogen through ammonium chloride and phosphorus through diammonium phosphate. But in case of wheat it was highest under the treatment receiving nitrogen through ammonium sulphate and phosphorus through single super phosphate. Nitrogenous fertilizers produced highest net return under the treatment receiving phosphorus through diammonium phosphate in case of rice and single super phosphate in case of wheat.

Benefit cost ratio was highest under the treatment receiving nitrogen through ammonium sulphate in both rice and wheat. But among the phosphatic sources diammonium phosphate was good for rice and single super phosphate for wheat.

CONCLUSION :

From the above findings, following conclusions can be drawn :–

I. Among the nitrogenous fertilizers, ammonium sulphate and ammonium chloride were equally effective for rice and wheat both, whereas the performance of urea was not up to the mark.

II. In case of phosphatic sources, diammonium phosphate was best for rice but single super phosphate was superior over other sources in case of wheat.

III. The interaction of ammonium sulphate with diammonium phosphate was best for both the crops this was followed by ammonium chloride and single super phosphate.

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APPENDIX

APPENDIX

Procedure for calculating cost of cultivation for rice and wheat on per hectare area basis: -

(A) For Rice Crop:

Sl. No.	Particulars/inputs	Quantity	Cost(Rs.)
I	**Common expenditure**		
1.	**Nursery raising**		
i.	Bed preparation (1/10 ha)		
	Tractor driven cultivator	Twice	50.00
	Harrowing by tractor	Twice	50.00
	Bed preparation (manday)	One	50.00
ii.	Seed	5 kg	500.00
iii.	Seed treatment by Bavistin	120 g	20.00
iv.	Sowing charges (manday)	One	50.00
v	Hand weeding (manday	Two	100.00
vi	Irrigation + application charge (manday)	Two	100
2.	Land preparation for main field		
	Tractor driven cultivator	Once	250.00
	Harrowing by tractor	Twice	500.00
	Puddling by tractor	Twice	600.00
	Levelling by tractor	Once	125.00
	Band preparation (manday)	One	50.00
3.	Transplanting charge (manday	Twenty	1000.00
4.	Cost of irrigation water	Twice	300.00
	Application charges (manday)	Four	200.00
5.	Weedicide/Hand weeding		
	Butachlor 50 EC	4 kg	1000.00
	Application charges (manday)	Two	100.00
	Hand weeding (manday)	Twenty	1000.00
6.	Plant Protection		
	Monocrotophose	1 litre	360.00
	Application charges (manday)	Two	100.00
7.	Fertilizer application charge (manday)	Four	200.00
8.	Harvesting of Produce (manday)	Thirty	1500.00
9.	Transportation		
	Bullock cart	One	75.00
	Labour charge (manday)	Two	100.00
10.	Threshing and winnowing (manday)	Twenty	1000.00
	TOTAL		**9380.00**

II.	**Variable expenditure**		
1.	**Phosphatic fertilizer**		
(i)	Diammonium phosphate (46%)	261.00 kg	1278.90
(ii)	Single Super Phosphate (18%)	571.40 kg	4685.50
(iii)	Nitrophos (16%, 16%)	571.40 kg	4399.80
2.	**Nitrogenous fertilizer (for S.S.P.)**	480.00 kg	2640.00
(i)	Urea (46 %)		
(ii)	Ammonium Sulphate (21%)	130.00 kg	1105.00
(iii)	Calcium Ammonium Nitrate (21%)	333.00 kg	1298.70
(iv)	Ammonium Chloride (25%)	375.00 kg	2215.50
3.	**Nitrogenous fertilizer (for DAP)**		
(i)	Urea (46 %)	238.00 kg	1162.20
(ii)	Ammonium Sulphate (21%)	548.00 kg	4493.60
(iii)	Calcium Ammonium Nitrate (21%)	548.00 kg	4219.60
(iv)	Ammonium Chloride (25%)	457.00 kg	2513.50
4.	**Nitrogenous fertilizer (for Nitrophos)**		
(i)	Urea (46 %)	201.00	984.90
(ii)	Ammonium Sulphate (21%)	511.00	4190.20
(iii)	Calcium Ammonium Nitrate (21%)	511.00	3934.70
(iv)	Ammonium Chloride (25%)	420.00	2310.00

(B)For Wheat Crop :

Sl.No.	Particulars/inputs	Quantity	Cost(Rs.)
I	**Common Expenditure**		
1.	Land proportion		
	Tractor driven cultivator	Twice	500.00
	Harrowing by tractor	Twice	500.00
	Leveling by tractor	Once	125.00
2.	Sowing		
	Seeds	120 kg	960.00
	Seed treatment by Bavistin	300 g	80.00
	Sowing charges (manday)	Five	250.00
3.	Use of weedicide		
	Isoproturon	2 kg	600.00
	2, 4-D	1 kg	200.00
	Application Charges (manday)	Two	100.00
4.	Irrigation		
	Irrigation water charge	Six time	1200.00
	Application charges (manday)	12	600.00
5.	Harvesting		
	Harvesting & Bundling (manday)	30	1500.00
6.	Transportation of produce		
	Bullock Cart	1	75
	Manday	Two	100.00
7.	Threshing and Winnowing		
	Electrical Thresher 5HP.	8 hr.	400.00
	Manday	Ten	500.00
	TOTAL		7690.00

II.	<u>**Variable expenditure**</u>		
1.	**Phosphatic fertilizer**		
(i)	Diammonium phosphate (46%)	261.00 kg	1278.90
(ii)	Single Super Phosphate (18%)	571.40 kg	4685.50
(iii)	Nitrophos (16%, 16%)	571.40 kg	4399.80
2.	**Nitrogenous fertilizer (for S.S.P.)**	480.00 kg	2640.00
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(iii)	Calcium Ammonium Nitrate (21%)	333.00 kg	1298.70
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(iii)	Calcium Ammonium Nitrate (21%)	511.00	3934.70
(iv)	Ammonium Chloride (25%)	420.00	2310.00

APPENDIX

Summary of cost of cultivation and economics (Rs/ha/annum) of the treatments in Rice crop

Treatments	Cost of Cultivation				Monetary Return				
	Common Expenditure	Variable Expenditure		Total	Grain Yield (q/ha)	Value of Grain (Rs/ha)	Straw Yield (q/ha)	Value of Straw (Rs/ha)	Total
		For N	For P						
N_1P_1	9380.0	1166.20	1105.0	11651.20	56.28	30391.2	81.40	4070.0	34461.2
N_1P_2	9380.0	1278.90	1298.70	11957.6	51.00	27540.0	76.30	3815.0	31355.0
N_1P_3	9380.0	984.90	2215.5	12580.4	43.50	23490.0	69.00	3450.0	26940.0
N_2P_1	9380.0	4493.60	1105.00	14978.60	57.20	30888.0	81.00	4050.0	34938.0
N_2P_2	9380.0	4685.50	1298.70	15364.20	52.85	28539.0	74.00	3700.0	32239.0
N_2P_3	9380.0	4190.20	2215.50	15785.7	48.68	26287.2	75.65	3782.5	30069.7
N_3P_1	9380.0	4219.60	1105.00	14704.6	54.05	29187.0	73.40	3670.0	32857.0
N_3P_2	9380.0	4399.80	1298.70	15078.5	50.93	27502.2	76.90	3845.0	31347.2
N_3P_3	9380.0	3934.70	2215.50	15530.2	51.38	27745.2	78.90	3945.0	31690.2
N_4P_1	9380.0	2573.50	1105.00	12998.5	63.35	34209.0	86.50	4325.0	38534.0
N_4P_2	9380.0	2640.0	1298.70	13318.7	52.98	28609.2	83.50	4175.0	32784.2
N_4P_3	9380.0	2310.00	2215.50	13905.5	48.38	26125.2	73.0	3650.0	29775.2

APPENDIX

Summary of cost of cultivation and economics (Rs/ha/annum) of the treatments in Wheat crop

Treatments	Cost of Cultivation				Monetary Return				
	Common Expenditure	Variable Expenditure		Total	Grain Yield (q/ha)	Value of Grain (Rs/ha)	Straw Yield (q/ha)	Value of Straw (Rs/ha)	Total
		For N	For P						
N_1P_1	7690.00	1166.20	1105.00	9961.20	46.05	28090.50	84.50	4225.00	32315.50
N_1P_2	7690.00	1278.90	1298.70	10267.60	49.80	30378.00	83.80	4190.00	34568.00
N_1P_3	7690.00	984.90	2215.5	10890.40	45.25	27602.50	83.95	4197.50	31800.00
N_2P_1	7690.00	4493.60	1105.00	13288.60	52.05	31750.50	92.75	4637.50	36388.00
N_2P_2	7690.00	4685.50	1298.70	13674.20	49.60	30256.00	90.80	4540.00	34796.00
N_2P_3	7690.00	4190.20	2215.50	14097.70	45.40	27694.00	82.65	4232.5	31826.50
N_3P_1	7690.00	4219.60	1105.00	13014.60	42.70	26047.00	77.40	3870.00	29917.00
N_3P_2	7690.00	4399.80	1298.70	13388.50	49.80	30378.00	85.05	4252.50	34630.00
N_3P_3	7690.00	3934.70	2215.50	13840.20	46.45	28334.50	80.90	4045.00	32379.50
N_4P_1	7690.00	2513.50	1105.00	11308.50	48.30	29463.00	83.80	4190.00	33653.00
N_4P_2	7690.00	2640.00	1298.70	11628.70	47.05	28700.50	90.75	4537.50	33238.00
N_4P_3	7690.00	2310.00	2215.50	12215.50	47.80	29158.00	78.85	3942.50	33100.5